The UNESCO Courier

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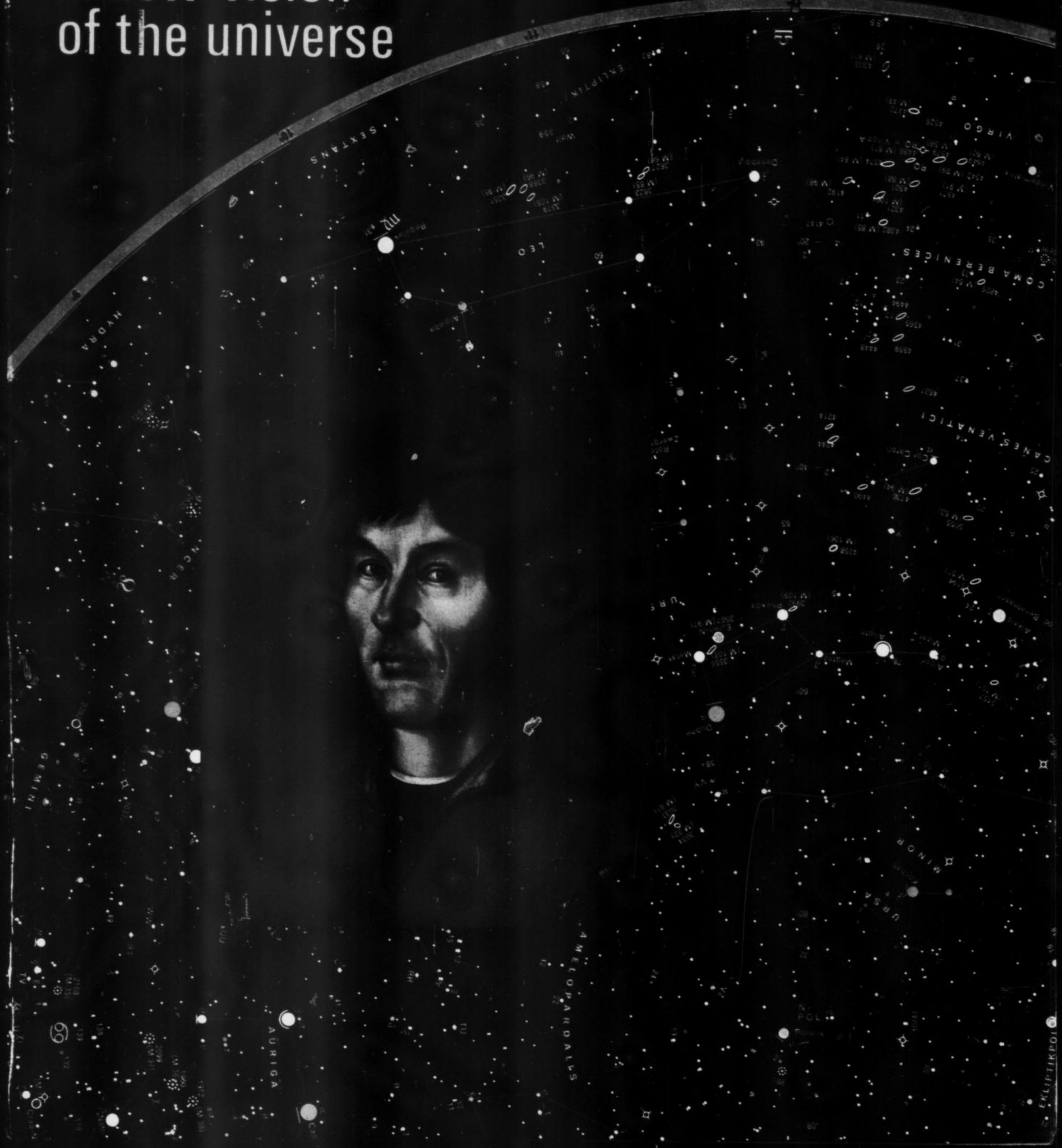
16 PAGES FOR CHILDREN

COPERNICUS
A new vision of the universe



TREASURES
OF
WORLD ART

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GREECE

God of the Cyclades

Dating from between 2400 and 2200 B.C., this head of a god, found on the Greek island of Amorgos in the Cyclades archipelago, is remarkable for the simple austerity of its style. This photo is taken from a lavishly illustrated book, *L'Art Grec*, published in 1972 by Editions Mazenod, Paris, with an introduction by the eminent Greek art specialist Kostas Papaioannou. An English edition is now being prepared for publication in the U.S.A.

Photo © Jean Mazenod, from "L'Art Grec", Editions Mazenod, Paris, 1972

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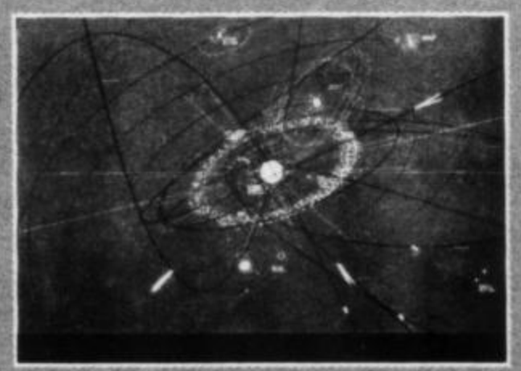


Photos © Hallwag, Bern, Switzerland

Photo Paul Almasy - "Unesco Courier"

COPERNICUS, A NEW VISION OF THE UNIVERSE

"This man has his place among the stars", it was said of Copernicus, and here against a fitting backdrop of a chart of the heavens we show a painting of the great astronomer by an unknown 16th century artist. Based on a self portrait, which has disappeared, it hangs in the town hall of Torun, Copernicus' birthplace. The stellar map in colour is novel in that it shows the position of the stars for the year 2000. Adapted by Werner Merkli and published by Hallwag (Bern, Switzerland) it measures 1.30 m × 1 m. Back cover reproduces part of a map of the solar system by the same publisher. The complete map carries reproductions of Mars, Jupiter and Saturn, and shows the size of all the planets in comparison to the Sun. The back of the map has detailed explanations of the solar system.

THE MANY FACES OF GENIUS. Copernicus as seen by seven young Polish artists whose entries for a sculpture exhibition await the judges' verdict in a storeroom in Torun, the great astronomer's birthplace. (See also page 27.)

Photo Paul Almasy - " Unesco Courier "

"History affords few examples of scientific discoveries that have had such profound repercussions on the spiritual development of mankind as that of the great Polish astronomer Nicholas Copernicus." It was with these words that Unesco's Director-General, René Maheu, opened a ceremony held in Paris on February 19th in honour of the 500th anniversary of the birth of the man who set the earth a-spinning round the sun and sparked off an unparalleled revolution in scientific methodology and thought. In this issue the **Unesco Courier** ***examines Copernicus' contributions to the progress of science and, exceptionally, publishes a 16-page supplement for children on the great astronomer.*** **Unesco Courier** ***photographer Paul Almasy made a special trip to Poland and elsewhere to follow in the footsteps of Copernicus and brought back a pictorial record of the life and times of one of the great figures of science whose guiding principle in life was " to seek the truth in all things ".***

IN THE FOOTSTEPS OF COPERNICUS

by Jerzy Bukowski

NICHOLAS COPERNICUS, the first of the great scientific thinkers of modern times, was born in the northern Polish town of Torun on February 19, 1473. His horoscope, which still exists, even gives the exact moment of his birth: 4.48 a.m., though this detail could be pure imagination on someone's part.

Copernicus, famous as the originator of the heliocentric theory of the universe, is less well known for his achievements as a humanist and classical scholar. With his vast erudition and profound interest in a wide range of problems, his insight as an investigator and his bold creative thinking and critical judgement, he was, in the words of one of his first biographers, "fired by an ardent passion for truth". His extraordinary intellect places him among the world's greatest men of genius, but he was also a citizen deeply concerned with his country's problems.

JERZY BUKOWSKI, *professor and former rector of the Warsaw Polytechnical Institute, is president of the Nicholas Copernicus Committee of the International Union of the History and Philosophy of Science. A former president of the Committee of the History of Sciences and Technology of the Polish Academy of Sciences, he is currently vice-president of the Polish Peace Committee.*

No documented historical evidence exists to tell us about the great astronomer's childhood and early youth. His father, also named Nicholas, was a Cracow merchant belonging to a family of Silesian origin, whose multiple interests had built up close links with the towns of Pomerania.

Nicholas Copernicus the elder became a burgher of Torun in 1458, and within a short time occupied a place of considerable social standing. After his death in 1483 his children, of whom the youngest, Nicholas, was ten years old, were placed under the guardianship of their maternal uncle, Lucas Watzenrode, future Bishop of Warmia, who was at the time a high-ranking dignitary of the Church and a distinguished statesman attached to the Polish royal court in Cracow.

Cracow was at that period the capital of Poland, which was then at the height of its power, and of which one of the great Italian humanists of the early 16th century was to say, "of all the lands beyond the Alps none equals Poland in its love of learning."

Torun was a flourishing town with prosperous trade and industries. As an intermediate point for merchandise routed through the ports of Gdansk and Elblag, it held a key position in overseas trade which assured it a place of considerable importance in the Polish economic system.

The two towns, which even today retain their medieval character, are situated upon the upper and lower Vistula respectively. Not far from Elblag, in the eastern part of the valley of the Vistula, stood the town of Frombork, where Copernicus was to spend the latter part of his life and where he died in 1543.

In the mid-fifteenth century, the political situation of the towns of the Baltic coastal province was extremely complicated. With Gdansk, Elblag and Torun foremost among them, they were engaged in a stubborn struggle to rid themselves once and for all of the hegemony of the Teutonic Order, which had settled in the region as far back as the 13th century. The Treaty of Torun, signed in 1466, restored Polish royal sovereignty over the Baltic coastal region, together with the delta of the Vistula, and including the major towns and the episcopal duchy of the Diocese of Warmia.

Both Nicholas Copernicus the elder and the Watzenrode family played an active role in achieving this agreement. To the end of his days, Lucas Watzenrode was to exert a vital influence

CONTINUED NEXT PAGE

upon the life of young Nicholas Copernicus, guiding his studies and setting the course of his future ecclesiastical and political career.

A second date confirmed by documents relating to Copernicus' youth is that of his registration at Cracow's Jagiellonian University in the autumn of 1491.

The Jagiellonian University was then at the height of its expansion; it was the only university in Europe to have two chairs of astronomy, and was renowned for the exceptionally high level of its teaching of the mathematical sciences. Studies there covered not only the treatises of the ancient Greeks, but even those of the scholars of Islam.

It was at Cracow that the young Nicholas Copernicus acquired his first notions of astronomy, and tradition has it that the famous astronomer and mathematician Wojciecj Brudzewski was among his teachers. During his studies at the Jagiellonian University, Copernicus obtained a thorough knowledge of Aristotelian and Ptolemaic astronomy and Euclidian geometry.

Judging from the books he bought at this period, which are fortunately still in existence, his main interest lay in spherical geometry and trigonometry, and in theoretical astronomy.

ALTHOUGH they differed on points of detail, Aristotelian and Ptolemaic theories, which had prevailed for over a thousand years, concurred upon two major fundamental postulates: firstly, the position assigned to the Earth as the immobile centre of the universe, and secondly, the attribution of a uniform circular motion to all the heavenly bodies—fixed stars as well as planets, and including the Sun and the Moon. The latter principle, a Platonic axiom, was to have a weighty influence upon the form first given by Copernicus to his heliocentric system of the universe.

Aristotle and those who professed and perpetuated his philosophy, as well as the astronomers and, in particular, Claudius Ptolemy, in his treatise known as the *Almagest*, give a truly remarkable description of the movements of the heavenly bodies, based on the two principles mentioned above, although a number of contradictions and anomalies were inevitably embodied in their theories.

Copernicus became aware of the discrepancies contained in the systems generally accepted and taught, and through mathematical analysis and geometrical synthesis, followed by minutely detailed observation of the sky, he gradually developed the idea of a heliocentric system of the universe.

Nicholas Copernicus probably spent four years in Cracow, and in the autumn of 1495 he was once again at the court of his uncle Lucas Watzenrode, who made unfruitful efforts to have his nephew appointed canon of the Chapter of Warmia in Frombork.

His failure to do so may have been the decisive factor in the destiny of young Nicholas. His uncle sent him to continue his studies at the University of Bologna, where he himself had studied as a youth, strongly recommending him to obtain the degree of doctor of canon law, with a view to pursuing an ecclesiastical career.

Copernicus left for Italy in the autumn of 1496, and remained in Bologna until the spring of the jubilee year 1500, although Bishop Watzenrode had in the meantime managed to have a canonry of the Chapter of Warmia conferred upon his nephew by 1497. The presence of famous scholars at the University of Bologna enabled Copernicus to perfect his knowledge of astronomy while at the same time pursuing his canonical studies.

Copernicus' first recorded observation dates from this period: that of the eclipse of the bright star Aldebaran in the constellation Taurus by the Moon, on March 9, 1497. The observation carried out in Bologna contradicted the Ptolemaic theory of lunar motion, and although it did not attack the fundamentals of geocentric astronomy, it nevertheless demonstrates Copernicus' critical approach to traditionally accepted theories.

According to Ptolemaic theory, the Moon should be much nearer the Earth at the quadratures and during the full and new Moon, but the careful observations made by Copernicus in Bologna showed that the Moon's parallax at quadrature was virtually identical to the parallax of the full Moon. In other words, the distance between the Moon and the Earth remained unchanged in either of these positions.

Criticism and denial of the old systems gave way to positive research, which led to the construction, upon the shattered remains of outdated theories, of a new system much closer to the actual truth. This is clearly demonstrated by the persevering studies carried out by Copernicus. He was in Rome during the great Jubilee year of 1500, worked for some time in the Vatican Chancery and, according to tradition, gave public lectures in astronomy.

In the spring of 1501, the young scholar returned to Poland to take up officially his post in the Chapter of Warmia: the Chapter gave him permission to go back to Italy, with injunctions to study medicine at the University of Padua. Copernicus lived in Padua for two years until 1503, apart from a few weeks spent in Ferrara, where on May 31, 1503 he obtained the degree of doctor of canon law.

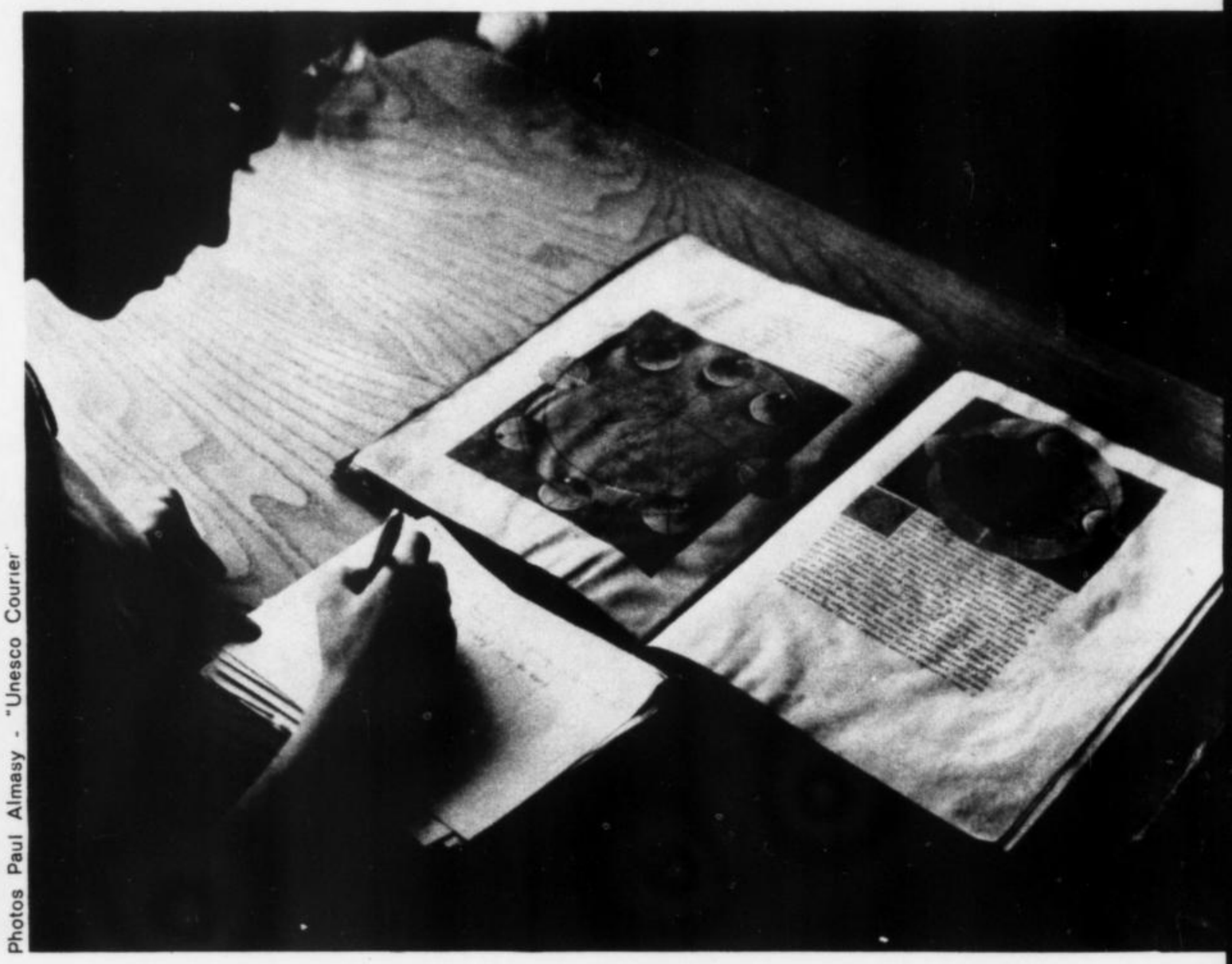
The extent and depth of Copernicus' studies in Padua and his later interest

CONTINUED PAGE 8

14th-century

'pearl of learning'

Above, the courtyard of the Collegium Maius at the Jagiellonian University, Cracow. The University's foundation charter, dating from 1364, described it as "a pearl of learning". During Copernicus' four years as a student there (1491-1495) the University was ravaged by fire and the original Collegium Maius was destroyed, to be replaced in 1494 by the present magnificent building. Left, the Jaque Fountain near the church of St Mary, Cracow, surmounted by the figure of a student in the scholastic dress of Copernicus' day. Below, a present-day student makes notes from a book on astronomy dating back to Copernicus' day.



Photos Paul Almasy - "Unesco Courier"

Photo Paul Almasy - "Unesco Courier"

8 **The statue of Copernicus in the Old Town Square at Torun and the house in which he spent his boyhood from the age of seven. The original house was demolished in 1906 to make way for a department store, but the two upper storeys were rebuilt in the style of the period.**

in this field are indicated by the heavily annotated works on medicine and natural sciences found in his personal library—fifteen or so of these books are still preserved in Uppsala University Library (Sweden).

At the end of 1503, Copernicus once again returned to Warmia, where he joined his influential uncle Lucas Watzenrode in his residence at the episcopal palace of Lidzbark. As the Bishop's doctor and secretary, he accompanied him on his frequent travels, and historical evidence shows that his office gave him ample opportunity to practise his medical skills.

Copernicus was consulted by a great number of important people, and he treated a wide variety of ailments, and of particular interest are his later activities as a specialist in public health and epidemiology, which he carried out alongside his administrative duties in the Chapter of Warmia.

During the ten years he spent with Bishop Watzenrode, Copernicus was inevitably drawn into political life. It is certain that his sense of responsibility in public affairs, of which he gave abundant proof during the following years, derives from this period. It is most probably from this time too that he became increasingly interested in the economic problems with which he was already familiar through his observation of the expansion of trade and industry in the Italian towns he visited during his years of study.

One thing which should be underlined is that Copernicus' stay in Lidzbark in no way diverted his attention from his main subject of interest, astronomy. It was in fact during this period that he finally and irrevocably formulated his brilliant thesis deposing the earth from its central position, and decided to put into writing the fundamental postulates of the new astronomy.

This he did, in a treatise which was not put into print, but was distributed only in a very limited number of handwritten copies under the title *Nicolai Copernici de hypothesibus motuum coelestium a se constitutis commentariolus*. (Nicholas Copernicus' Commentary on the Hypotheses of the Movement of the Celestial Orbs.)

The exact date of the *Commentariolus* is unknown, but it was probably written shortly before 1509, during which year a further aspect of Copernicus as a classical scholar was revealed In 1509 the letters of the 6th century Byzantine writer Theophylact Simoccata appeared in Cracow in a translation by Copernicus from Greek into Latin.

Two dates mark the beginning of a new phase in the life of Copernicus: 1510, the year of his installation at Frombork and 1512, with the death of Bishop Lucas Watzenrode. As he approached his fortieth year, Coper-

CONTINUED PAGE 19

The castle at Olsztyn, Poland, where Copernicus lived for several years. From 1516 to 1519 it was his residence as administrator of the properties of the Chapter of Warmia. He returned to Olsztyn in 1520 on the outbreak of hostilities between Poland and the Teutonic Knights to organize the defence of the fortress against a threatened siege. Despite his many tasks, Copernicus continued his astronomical studies, using the big, first floor room whose windows are seen in this photo. Left of photo, the statue of an ancient divinity of the region which already stood in the castle courtyard in Copernicus' day.

Photo Paul Almasy, "Unesco Courier", Paris

Copernicus noted down his first astronomical observation while studying at the University of Bologna (Italy) between 1496 and 1500. On the roof of the university observatory (right) he used his astronomical quadrant, here silhouetted against the evening sky, to observe an eclipse of the moon on March 9, 1497. Alongside the quadrant are the Alfonsine planetary tables, compiled for Alfonso X of Castile by Arabic, Jewish and Christian scholars between 1248 and 1252. Lying beside the tables is an early printed edition of the *Almagest*, the astronomical and mathematical encyclopaedia written in the 2nd century A.D. by Claudius Ptolemy, of Alexandria.

The foundation of modern science

From his 'remote corner of the world' Copernicus set in motion not only the Earth, but the entire spirit of research

by Owen Gingerich

TO a modern scientist, science of the 15th century has a strange and unfamiliar quality. When Copernicus was born, men believed that a weightless, crystalline sun whirled daily around the earth. Celestial motions were explained in terms of strivings inherent in matter itself. Professors of physics said that a stone thrown from the hand flew straight until it ran out of "impetus" and then fell directly down to the ground.

In 1543 Copernicus' masterpiece, *De revolutionibus* ("Concerning the Revolutions"), was published, and in the century that followed, the curious, time-honoured scientific explanations of antiquity and the Middle Ages gave way to the ideas that form the foundations of today's science.

A great change—indeed a revolution—took place in that age, with Copernicus at its forefront. Far more than political struggles, with their attendant fleeting changes, the work of Copernicus and his intellectual successors has shaped our contemporary world.

If indeed Copernicus' contributions triggered off the entire sequence of ideas that have become modern science, we may well ask why this is a phenomenon only 500 years old. What prevented the appearance of a Copernicus a century or two before? Was an earlier great unfolding of science prevented by bonds of dogma and ignorance?

Or, in a contrary view, should we consider creative science a delicate and fragile plant that blossoms forth only in particularly germinal conditions? Perhaps it was not mere coincidence that the great astronomer lived as a

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OWEN J. GINGERICH, *a leading American astrophysicist, is professor of Astronomy and the History of Science at Harvard University, and has taken part in Harvard astronomical research expeditions to several countries, including Sri Lanka and Lebanon. He is also an astrophysicist at the Smithsonian Astrophysical Observatory, in Cambridge, Massachusetts. His publications include many studies on the history of astronomy and the applications of computers to this subject.*

Photo Erich Lessing © Magnum, Paris

contemporary of Columbus, Dürer, Leonardo, Erasmus, and Luther. In that case we can make a fascinating inquiry: what factors contributed to the remarkable flowering of science typified by Copernicus?

The geocentric astronomy of Copernicus' day had served well for over a thousand years; it meshed perfectly with man's view of himself and with the primitive physics of Aristotle. To be sure, learned prelates recognized that Easter was coming too early in the calendar year, and a few astrologers knew that the planets were sometimes found several degrees from positions predicted by tables based on the venerable Ptolemaic theory. But if there were a crisis in astronomy, Astronomia had just as much of a problem on her hands after Copernicus as before, for the calendar remained the same and planetary predictions were improved only a little.

No one knows precisely how or when the Polish astronomer first seized upon the idea of a sun-centred system; in any event, by 1515 he was hard at work on his manuscript of *De revolutionibus*, a book that encompassed both his new cosmology and a careful re-examination of old and new planetary observations.

Nor do scholars know *why* he adopted a heliocentric view of the cosmos, for the observations of his day could neither prove nor disprove his idea. Nevertheless, there is a clue in his own writings.

A euphoric sense of beauty pervades the entire composition of the book: *For in this most beautiful temple, who would place this lamp in another or better position than that from which it can light up the whole thing at the same time?... We thus discover a marvellous symmetry of the universe and a fixed harmonious linkage as can be found in no other way... So vast is this divine handiwork of the most excellent Almighty.* Surely an aesthetic vision gripped Copernicus and guided his analysis of the heavens.

Yet it is a curious and nearly forgotten fact that the Copernican Revolution was nearly stillborn. Two decades after he had begun his book, Copernicus had run out of steam. By then in his sixties, he had written the most profound astronomical treatise in a millenium, but the small technical details lacked a final polish and inner consistency. His manuscript was a work of beauty, with exquisitely drafted figures and two-colour tables, but

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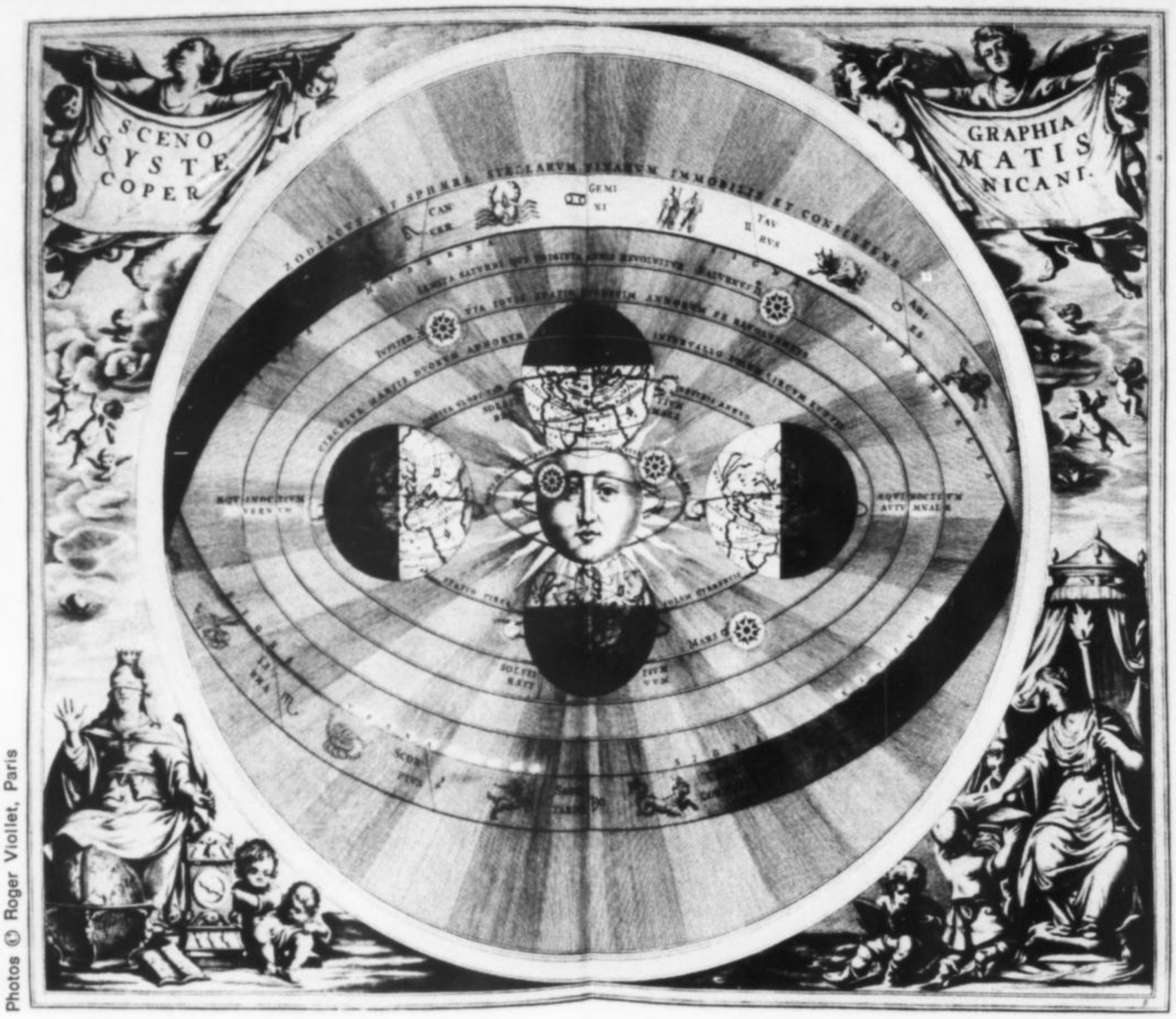

Photos © Roger Viollet, Paris

THE BOOK THAT MOVED THE WORLD

The original manuscript of Copernicus' "On the Revolutions of the Heavenly Spheres" is both a major scientific treatise and a work of art. Written in cursive and formal styles of the 16th century, the text is illustrated with many astronomical diagrams, inset in certain passages or placed in the margins. As an anniversary tribute to Copernicus a full colour fascimile of the manuscript (now in the Jagiellonian University Library, in Cracow) is being published in several countries. Right, the famous diagram from the manuscript in which Copernicus summarises his conception of the Universe with the earth placed in an orbit around the sun exactly similar to those of the other planets. Left, a later illustration of the Copernican system published in Amsterdam, in 1661, in *Harmonia macrocosmica* (or New Universal Atlas) by Andreas Cellarius. Though it appeared over a century after Copernicus' death, this work carried only one illustration of his theory of the universe.

these paper folios had apparently been designed as the end-product itself.

His post as canon of the Frombork cathedral in Poland had given him financial security and time for contemplation, but it deprived him of stimulating intellectual companionship. In short, there was no one to talk to about his remarkable book, that had been so long in the making.

Although Copernicus had found printed works essential in his own studies, printing was still a comparatively new invention, one that had begun to flourish only during his own lifetime. There was as yet no printer in Frombork, and the aging astronomer apparently had no intention of publishing his work elsewhere.

De revolutionibus seemed destined to gather dust in the cathedral library, to be forgotten and ignored. Such a fate seems incredible to us today—yet it must have overtaken scores of astronomical achievements of the Middle Ages.

But in 1539, in Copernicus' last years, a young mathematician from Germany appeared in Frombork, eager to learn the details of the astronomer's ideas. George Joachim Rheticus, already a professor at Wittenberg though just in his mid-twenties, had heard rumours of the innovative Copernican astronomy.

Although the young Rheticus came from the hot-bed of Lutheranism, the Catholic Copernicus received him with courage and cordiality. Caught up by the enthusiasm of his young disciple, Copernicus made last-minute revisions to his opus and then entrusted a manuscript copy to Rheticus for publication.

Rheticus took the manuscript to a printer in Nuremberg, who finished the production of several hundred copies in 1543. These were sold to scholars and libraries throughout all of Europe. And thus it came about that the new technology of printing was able to play an absolutely essential role in preserving and disseminating the new astronomy.

The readers of Copernicus' treatise gladly accepted his new planetary observations and his careful attention to the details of planetary orbits, but the heliocentric world view itself found little support. In our own age of space exploration, when men have looked back upon the spinning earth suspended in the skies, the Copernican system seems natural, almost obvious. But to most astronomers of the late 1500s, imbued with the physics of Aristotle, a moving earth had little appeal. Instead, they chose a primitive form of relativity.

Keeping the earth as their fixed reference framework, they viewed the Copernican system as a clever mathematical model, somewhat more complicated than the old Ptolemaic system, but not a true description of the physical world. There was certainly nothing obvious about a moving earth and a fixed, central sun; Galileo later remarked that he could not admire enough those who had accepted the Copernican system *in spite of* the evidence of their senses.

NEVERTHELESS, Copernicus' *De revolutionibus* acted like a delayed action bomb. Around 1600 two great scientists, each in his own individual way, grasped a truth in the heliocentric system that went beyond geometrical model-building. Johannes Kepler saw in the sun-centred spacing of the planets a harmonious, aesthetic relation that could be expressed in mathematical relations. He envisioned a force emanating from the sun, and built a "new astronomy or celestial physics based on causes."

In Italy, Galileo Galilei turned the newly invented telescope to the heavens where he found one astonishing suprise after another. The moon, filled with mountains and plains, traversed the skies as another earth-like planet. And Jupiter, with its own retinue of moons, became a miniature Copernican system. To Galileo the universe was comprehensible as a unity only if the earth was a planet revolving about the distant, fixed sun.

Both Kepler and Galileo differed strongly from an anonymous introduc-

Photo © Erich Lessing - Magnum, Paris

tion that had been added to *De revolutionibus* when it was printed. In that introduction the Lutheran theologian Andreas Ossiander stated a widely-held philosophical opinion: astronomical theories were mathematical models intended for predictions of astronomical phenomena, and whether they were ultimately true or false was irrelevant.

Such a view is logical and self-consistent, but Kepler and Galileo were convinced that their astronomy gave a true picture of the universe. This claim, plus their opinion that in matters of science the Bible simply spoke in the plain terms of common man so as to be understood, brought them into conflict with the Catholic Church, and consequently several of their works were placed on the *Index of Prohibited Books*.

To a 20th century scientist, familiar with the concept of relativity, it may seem ultimately irrelevant whether the earth or sun is the chosen fixed reference point. But the 17th century collision between religious dogma and an innovative world view has had a profound impact on mankind's views concerning the source and nature of truth about our physical world. And in the 17th century it *did* make a difference whether the universe was conceived in geocentric or heliocentric terms, because only a heliocentric solar system leads onward to Newtonian physics.

In turn, Newton's laws of motion and his law of Universal Gravitation describe the orbits of satellites and space probes. Thus there is a direct line from Copernicus through Kepler, Galileo and Newton to the marvels of our own space age.

No doubt Copernicus would have been astonished to learn that the world would link his birthday to a celebration of modern science. An unwitting revolutionary, his goal was to return science to a purer state, conceived in terms of the perfect circles of the ancient Greeks. He sought a view "pleasing to the mind," and he gave to the mind's eye a fruitful new way of looking at the cosmos.

Still, our earlier question comes back to haunt us. Why did this new view wait until the early 1500s? The answer lies not so much in the science as in the society and in newfound patterns of communication. The invention of printing and the rise of universities encouraged the flow of information and new ideas. The discovery of America, while Copernicus was a student at Cracow, helped demonstrate the inadequacy of traditional knowledge. A seething intellectual milieu, absent a century or two earlier, characterized the age.

Furthermore, Copernicus had a patron—the Frombork cathedral chapter—that enabled him to travel to Italy for graduate study, and which freed him from financial worries. More importantly, he had the time and freedom to contemplate and choose innovative views.

In that age of change, a new mobility of ideas brought Copernicus fresh knowledge that he required for building his system, and at the end of his life this same combination of travel, freedom, and printing saved his work from oblivion.

The new-found freedom of inquiry, combined with the requisite intellectual resources and the discipline to work out the consequences and to test the data—this is without doubt more important for the rise of modern science than the specific idea of a sun-centered cosmology.

We learn more for our own age from Copernicus' persistence, his eagerness to seek learning beyond his own provincial boundaries, his willingness to share with those outside his own religion and nation, than we learn from his formidable astronomical tome or from his paeans to the heliocentric cosmology.

From his "remote corner of the world" Nicholas Copernicus set into motion not only the earth, but the entire spirit of inquiry that has so richly increased our understanding of the universe. But the ultimate reason for the anniversary celebration—and indeed its challenge—is a re-dedication to preserve the fragile freedom of inquiry and the resources that make inquiry possible. ■

The making of a new universe

Why Copernicus was dissatisfied with the astronomy of his time

by Olaf Pedersen

WHEN Alexander Pope wrote his famous couplet:

Nature and Nature's Laws lay hid in [night;
God said, Let Newton be! — and all was light

he gave vent to a common feeling towards prominent figures in the history of science.

Posterity has always been inclined to regard men like Newton, or Einstein, or Darwin, as radical innovators who, all of a sudden and without previous warning, changed the general course of science and as a consequence perturbed the whole attitude of man towards the universe.

Certainly this has been the fate of Copernicus who more than any other scientist has been hailed as the first harbinger of modern astronomy after the long scientific somnolence of the Middle Ages.

That such a view could emerge was connected with the fact that the basic principles of Copernican cosmology were simple enough to be accessible to a large public.

First, the Earth was set spinning around its own axis. In Copernicus' own words: *Together with its surrounding elements the Earth during a diurnal motion performs a complete revolution round its fixed poles, while the firmament and the highest heavens remain motionless.*

It is true that this idea was neither new nor unknown to the late Middle Ages, but it was so contrary to ingrained conceptions that very few had been able to believe in it or assert it as true.

Next the Earth was removed from its traditional position: *The centre of the Earth is not the centre of the Universe . . . All spheres rotate about the Sun as their central point and therefore the Sun is the centre of the Universe,* that is, of the planetary system and the distant sphere of the fixed stars which still was the outer boundary of a world that even to Copernicus remained spherical and of a finite size.

Finally, the Earth was deprived of its unique character and reduced to a mere planet among others: *That which to us appears as a movement of the Sun is not due to any motion of the latter, but to a motion of the Earth . . . during which we rotate about the Sun like any other planet.*

Such assertions were clearly incompatible not only with time-honoured

CONTINUED PAGE 16

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The Dragon (Draco)

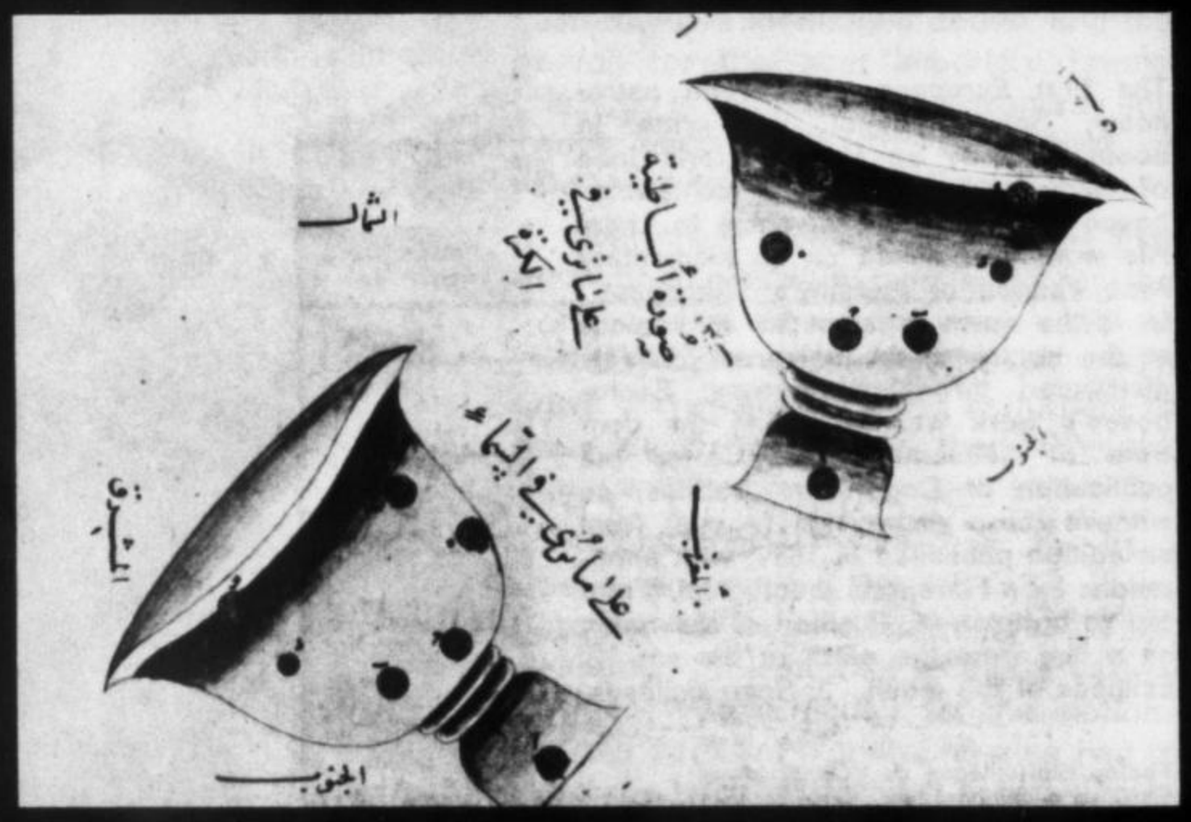
Ancient symbols of the constellations

The Virgin (Virgo)

In De revolutionibus, *Copernicus refers to observations made by early Islamic astronomers, and one work he may well have known about was the famous "Treatise on the Fixed Stars", written in Arabic by the 10th century Persian astronomer Abd ar-Rahman As-Sufi. Early in the 15th century, Ulugh-Beg, grandson of Tamerlane and ruler of the Timurid empire which spread over vast areas of Central Asia, ordered calligraphers to make a copy of the "Treatise". The richly illuminated work was completed in time for a conference of astronomers summoned by Ulugh-Beg to Samarkand in about 1435. The illustrations, unique in Islamic art, were the work of a Persian artist living in Samarkand and show evidence of Chinese influence. The paintings are mat colour-washes, scarcely coloured at the edges, typical of the Chinese technique of the period. The figures are depicted in Mongol dress which was the fashion in the Timurid empire. The captions, in literary Arabic, give the names of each constellation and indicate the cardinal points and angles from which the constellations are seen.*

The Strong Man (Orion)

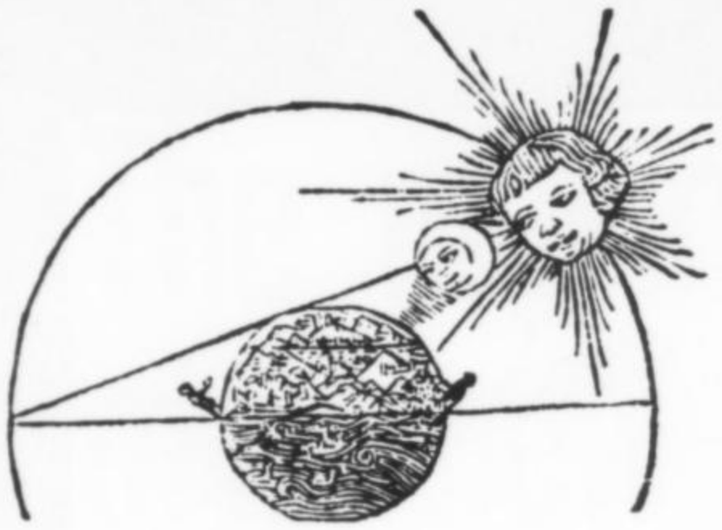
Pegasus (Caption reads—"Perhaps the moon has descended into the village of the fox")

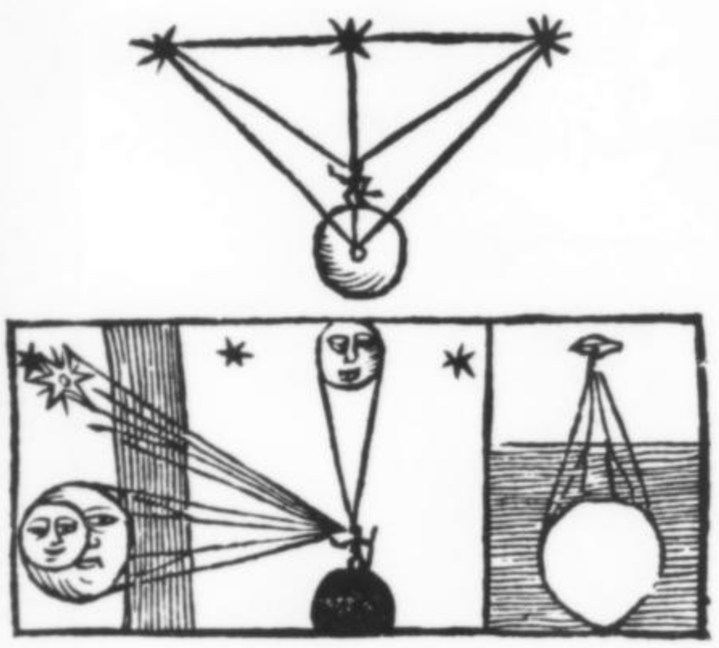


Two positions of The Cup (Crater) in the southern hemisphere

Photos © Bibliothèque Nationale, Paris

Aristarchus of Samos: the man forgotten by Antiquity





The first European treatise on astronomy, "Sphaera mundi", was written in about 1230 by an English cleric John of Hollywood, or Johannis de Sacrobosco as he signed his name in Latin. His work was based on an elementary Arab version of Ptolemy's "Almagest". In it the earth is seen as motionless at the centre of the universe. Widely distributed throughout Europe, Sacrobosco's work was spreading the doctrine of geocentrism long after the publication of Copernicus' studies, as witness these engravings (above) from an edition published in 1567, with annotations by a Florentine theologian. From top to bottom: 1. Position of the moon on a line from the earth to the sun. 2. Eclipses of the moon. 3. Solar eclipses.

Photos Bibliothèque de l'Observatoire - © Claude Michaelides, Paris

conceptions of the universe but also with the belief in man's favoured abode near the very centre of all creation. This explains why the inevitable clash between the rival cosmologies had to spread far beyond scientific circles, arousing an ideological combat on a scale and of a ruthlessness which the world was not to see again until the coming of evolutionism challenged a different, but equally cherished set of ideas about the uniqueness of man.

Thus the Copernican revolution became a paramount factor in the intellectual development of mankind, and we have sufficient reasons for honouring the memory of the man who first inaugurated it.

But along with general or popular discussions went the more careful deliberations of professional astronomers on the more technical implications of the new theory. Copernicus had himself clad it in the well-known mathematical language of traditional astronomy.

Consequently his great work, *De revolutionibus orbium coelestium* (Concerning the Revolutions of the Celestial Spheres), was intelligible to anybody who knew and understood Ptolemy's *Almagest* upon which it was modelled. This meant that all competent scholars were soon forced to admit that Copernican astronomy was acceptable as a possible and consistent mathematical hypothesis.

But this was not the crux of the matter. Any careful reader of *De revolutionibus* would realize that Copernicus went much further, claiming his theory to be true in the sense that it gave a correct picture of the physical structure of the universe. This claim was the starting point of the extraordinary scientific development following in the wake of Copernican astronomy.

On the one hand it gave rise to the attempts at verifying the new theory by means of observations, first and foremost through a search for the annual parallactic motion of the fixed stars implied by the movement of the Earth around the Sun. This work occupied successive generations of practical astronomers from Tycho Brahe onwards until in 1838 it was finally crowned by success when Bessel succeeded in determining the parallax of the star 61 Cygni.

On the other hand the claim that the Copernican system was true in a physical sense guided Galileo and many other physicists in their attempts to create a theory of mechanics compa-

Below, books from Copernicus' own library, now preserved at Uppsala, Sweden. The volume adorned with spheres is the great Roman calendar of 1518, drawn up by the German astronomer Johann Stoffler, who died in 1531. Right foreground, the first printed edition (1515) of the "Almagest" by Ptolemy, the renowned Greek astronomer whose geocentric theories held sway until overthrown by Copernicus.

Photo Owen Gingerich, Cambridge, U.S.A.

tible with the new astronomy and able to remove the obstacles raised by the traditional, Aristotelian physics, in particular the doctrine of natural motion and natural place, and the conception of gravity as a force directed towards the centre of the universe. The majestic structure of classical, Newtonian mechanics was the final outcome of this struggle.

These few remarks will suffice to justify the opinion that Copernicus is one of the founders of the modern world, both in the ideological and scientific sense. It is no wonder that both the history of ideas and the history of science have found a wealth of material in the Copernican heritage and that they are still far from having exhausted it.

On the other hand we must admit that Copernicus presents also other problems of a more intriguing nature. Certainly, to prove his importance it is enough to point to the consequences of his achievement; but to evaluate his greatness it is also necessary to examine the background of his work.

No single event in the intellectual history of mankind exists in isolation. It has its antecedents, and although individual scientists occasionally succeed in presenting the world with a new idea, there will always be certain conditioning influences for which the historian has to search—not in order to deprive the real innovator of his creative genius, but to put it into a broader perspective and underline the fundamental continuity of the historical process.

COPERNICUS had his scientific initiation at the University of Cracow which was deeply imbued with the spirit of the Viennese astronomers Peurbach and Regiomontanus. As good Humanists they had tried to reform astronomy through a conscious return to its classical sources, for instance by undertaking a new and improved translation of Ptolemy's *Almagest*.

In the preface to *De revolutionibus*, Copernicus admits to a similar Humanist approach; in fact, his search through classical authors had led him to two Pythagorean astronomers, Hicetas and Ecphantos, who assumed a moving earth. However, this is practically everything we know about them, and one hesitates to regard such a slender tradition as the source of one of the major cosmological revolutions of all times.

And Copernicus' more aesthetic reflections on the most suitable position of such an august body as the sun may be regarded as a mere afterthought without real importance to the establishing of his cosmology.

A much more plausible inspiration would have been the famous Aristarchus of Samos who in the third century B.C. devised an heliocentric cosmology very similar to the Copernican system. In fact, the original manuscript of *De revolutionibus* devotes a long passage to Aristarchus who accordingly was well known to Copernicus who, nevertheless, deleted this very passage from the printed version of his book.

This remarkable omission is, indeed, hard to explain; perhaps Copernicus was afraid that the memory of how the heliocentric system was rejected in Antiquity might prejudice the acceptance of his own theory.

The surmise that Copernicus found in Aristarchus a point of departure for his own thought does not answer the fundamental question why he was so dissatisfied with the prevailing astronomical ideas that he had to seek an alternative description of celestial phenomena. This is a more intricate problem which cannot be illustrated by mere cosmological considerations without reference to theoretical astronomy and planetary theory.

Here it is evident that Copernicus was not concerned with renewing the mathematical tools of traditional astronomy. Like Hipparchus and Ptolemy he described the movements of the planets by constructing geometrico-kinematical models simulating the observable phenomena as closely as possible.

Ultimately everything had to be reduced to an interplay of circular motions which must be uniform about their respective centres, a fundamental assumption to which Copernicus adhered even more strictly than Ptolemy. In this respect Copernicus appears in a most traditional light and it was left to Kepler to introduce fundamentally new conceptions in the form of elliptical orbits.

Such geometrical models had to be provided with numerical parameters derived from observations. Here, too, Copernicus proceeded exactly in the same way as many Arabic or Latin astronomers, relying upon data recorded by Ptolemy or other ancient observers, and supplementing them by a few observations of his own.

Because a long span of time had elapsed since Antiquity this should lead to improved values of the various mean motions; but it is important to remember that such improvements are independent of cosmological considerations. A simple transformation of co-ordinates from a geocentric to a heliocentric frame of reference is unable to increase the accuracy of astronomical theories.

Accordingly we must conclude that the desire for more accurate theories was no argument for the Copernican system. On the other hand the new system could not be proved or disproved until observational astronomy was accurate enough to decide whether the fixed stars have a parallax, that is, a small, apparent displacement due to the annual motion of the Earth. This moved Tycho Brahe and later astronomers to improve observational techniques until finally in 1838 the effect was discovered by Bessel.

A new and unexpected light was shed upon some of the more technical details of the work of Copernicus when in 1957 V. Roberts showed that the beautiful theory of the moon's motion contained in. *De revolutionibus* was in every respect identical with the Lunar theory of the 14th century Damascene astronomer Ibn ash-Shatir.

Further research by V. Roberts, E.S. Kennedy, and F. Abbud proved also that the geometrical structure of the theory of Mercury was the same in the two authors. In particular they both make use of a special kinematical device for producing rectilinear motion by combining two circular motions. This device was invented by the 13th century Maragha scientist Nasir al-Din al-Tusi. W. Hartner has argued in a very convincing way that this remarkable agreement proves that Copernicus was influenced by Moslem astronomy through channels which remain to be identified.

These discoveries do not detract from the originality of Copernicus. There is not the slightest trace of heliocentric ideas in any of the Oriental astronomers mentioned above, and the credit for the most important breakthrough in the history of astronomy still goes undiminished to the author of *De revolutionibus orbium coelestium*.

Everything considered it seems that the most plausible motivation for the new system was Copernicus' earnest desire for a cosmology which would give more simplicity and uniformity to theoretical astronomy than the old, geocentric view of the universe.

In particular he seems to have been worried by two obvious shortcomings of Ptolemaic astronomy. First, although Ptolemy had to use a variety of geometrical models for the motions of the different planets, he also had to provide each model with a component,

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circular motion with a period of revolution of precisely one year.

Second, Ptolemy was unable to determine both the absolute as well as the relative distances of the planets from the Earth, so that their commonly accepted order was no more than an arbitrary convention.

Both these facts had been known since Antiquity, but no astronomer seems to have been seriously troubled by them until Copernicus showed how they could be overcome by a single remedy. Here we must admit that the heliocentric theory was a real stroke of genius.

Thus the annual period found in all planetary motions ceased to be a mysterious coincidence and became a simple consequence of the annual motion of the Earth around the Sun. One of the most enigmatic features of the motions of the planets had thus found a rational explanation.

A further consequence was that Copernicus could dispense with the five circles—usually called epicycles—which in Ptolemaic astronomy had been responsible for the annual period in the motions of the five ordinary planets. As a result the geometry of the whole planetary system became somewhat simplified, the role of the five epicycles being taken over by the one orbit of the Earth.

The final triumph of the Copernican system followed directly from this latter circumstance. Already Ptolemy had been able to determine (from observations) the ratio of the radius of each epicycle to the mean distance of the corresponding planet. The Copernican theory reduced, as it were, all the epicycles to the same size (viz. that of the orbit of the Earth). Consequently the mean distances of all the planets can be expressed in units of the radius of the orbit of the Earth.

To the greater clarity and simplicity of his system Copernicus was thus able to add the correct order, and exact distances of the planets from the Sun. For the first time in the history of astronomy the solar system became an ordered whole instead of an arbitrary structure.

The Copernican system had a prehistory comprising many separate elements—cosmological speculations of ancient astronomers, mathematical tools borrowed from Ptolemy and the Arabs, and a series of observations ranging from classical times to Copernicus himself.

The proper genius of Copernicus lay in the fact that he was the first to wonder at mysterious coincidences and arbitrary conventions with which lesser spirits had long ago come to terms. ■

At Torun, birthplace of Nicholas Copernicus, the secondary school is named in honour of the town's most famous citizen. Here, children proudly lift a bust of Copernicus to place it on a pedestal at the school.

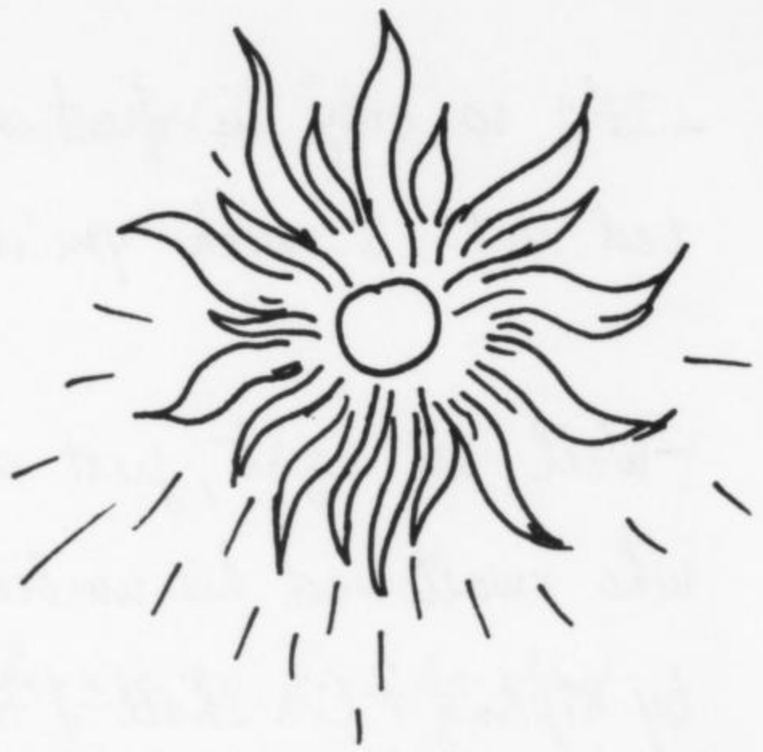
Photo © S. Figlarowicz, "Poland", Warsaw

Special children's supplement

We are pleased to publish on the following pages *Copernicus as told to children,* a 16-page supplement written specially for the "Unesco Courier" by Jean-Claude Pecker, professor at the Collège de France and director of the Institute of Astrophysics at the French National Centre of Scientific Research, in Paris. Secretary-General from 1964 to 1967 of the International Astronomical Union, Prof. Pecker is a member of the French National Commission for Unesco. Besides his many scientific studies, he has written several books for lay and young audiences. He is the author of a popular children's book in French, *Papa dis-moi, l'astronomie qu'est-ce que c'est ?* (Daddy, tell me, what is Astronomy?) published by Editions Ophrys, Paris, 1971.

The UNESCO Courier

APRIL 1973



The man who set the world a-spinning or COPERNICUS as told to children

Text and drawings
by Jean-Claude Pecker
Professor of Astrophysics
at the Collège de France

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–It's so cosy in front of the fire, Daddy. I don't want to go to bed yet. I wish you'd tell me a story.

–Well, all right, just one. Which story will it be? About the man who swallowed his umbrella? Or how about one of the "Just So Stories" by Kipling? Or shall I tell you a story from "Alice in Wonderland" or the "Arabian Nights"?...

–Daddy, please, I've heard all those stories several times. Tonight I'd like to hear a story about SOMEBODY REAL.

–SOMEBODY REAL? What do you mean by 'somebody REAL'?

–I don't know... Oh!... I remember seeing a picture of a man with long hair on the cover of a magazine. I've seen pictures of him in some of your books.

–I haven't the foggiest notion who you're talking about. Do you mean that long-haired pop singer on the cover of this week's T.V. magazine?

-No, I don't! I mean that magazine over there!

-NICHOLAS COPERNICUS?

-Is that his name? Who is he?

-You mean who <u>was</u> he, since he died a long time ago. In 1973 his five hundredth anniversary is being celebrated in many countries, and that's why his picture is in many of the magazines I read.

-500 years seems a long time ago. Was great-grandfather alive then?

-Good heavens no! It was long before he was even born. Work it out for yourself. Copernicus was born 500 years ago. My grandfather was born only a hundred years ago.

...It was a strange period in history. Europe was just coming out of the MIDDLE AGES. There had been the Crusades and a terrible war that lasted about a hundred years... People lived in little towns with narrow streets and were afraid to venture out into the forests or the mountains because there were packs of roving wolves and... ferocious bears, and... bands of robbers. But in these quiet little towns a new thing had happened. The universities...

... were being born. At that time there were also monasteries all over Europe where many many monks gathered to study, and began to carry out RESEARCH WORK just like your Daddy is doing today.

I have to admit that sometimes their research work was a little peculiar - even odd. They carried out experiments using all kinds of curved and squiggly retorts and other strange contraptions. You see, they were searching for the famous "philosopher's stone" that would change

LEAD into GOLD

At least that's what they thought. this was known as Alchemy.... They were also astrologers for they believed that the planets and the stars influenced men's lives. Believing in Astrology at that time can be excused since people had no idea, or at most only a vague idea, of how far away the stars really were. There are still astrologers today, and many newspapers and magazines unfortunately publish the silly horoscopes they write. Astrology may have been a reputable science in the 15th century but it can in no manner or fashion be considered a science today. In fact today's astrology is based on the false notions of astronomy that were popular during and long before Copernicus' lifetime.

Don't think it was easy to do scientific research in those days. It took a lot of courage. Remember, certain books were held in deep awe both by scholars and churchmen: especially the works of Aristotle of ancient Greece, and of course the Bible. It was believed that the answer to all questions could be found in those works. And no one could disagree with what they said. You may not know this, but alchemists were actually BURNED at the stake for practising witchcraft. And though their experiments make us smile today, they were REAL research workers, inquisitive and completely honest...

... like the scientists of today.

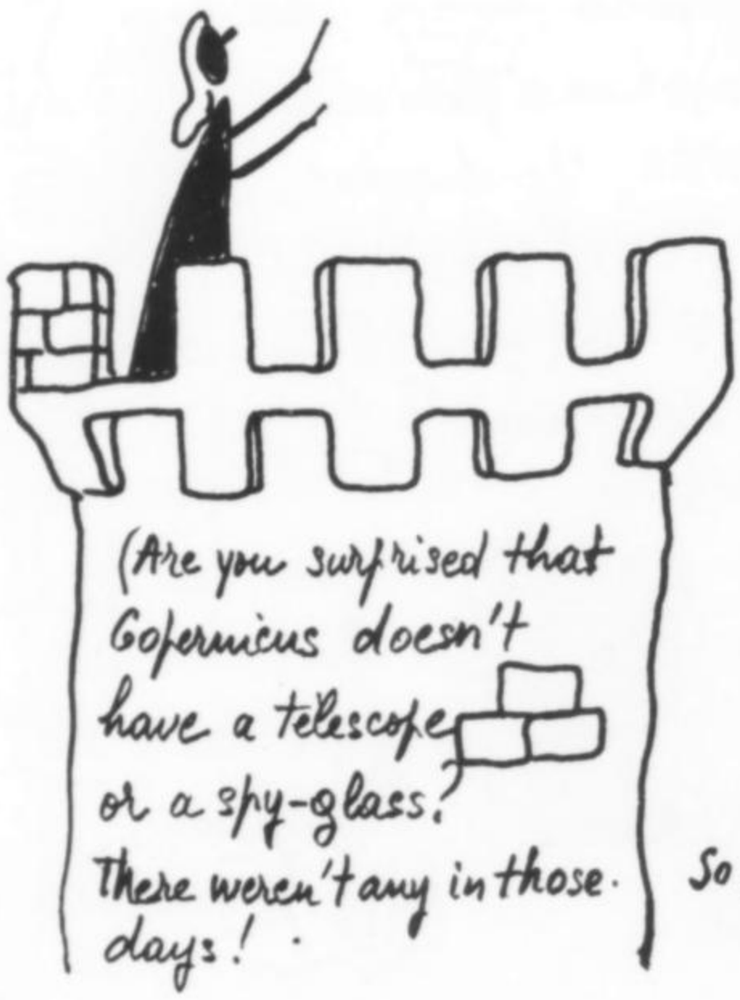
– But Daddy, when are you going to start talking about COPERNICUS?

– O.K., O.K., I hadn't forgotten him. As you saw from his picture, Copernicus had long hair and probably blue eyes and loved to gaze at the sky. He was an unassuming, gentle, modest man. He was born in a small town in Poland, called Torun. He was a very religious man. In fact he was ordained a Catholic priest and spent much of his life in the cold, wind-swept corner of Poland near the Baltic Sea, at Frombork. The town had a great big TOWER. My drawing may be off the mark but I think you get the idea – and that's what counts.

...and from his tower he often gazed at THE HEAVENS

But he was very careful about keeping the account books of the monastery where he lived, and he faithfully obeyed the laws of the Church of Rome...

—Daddy, I've heard about all the student and teacher protest movements nowadays. Were there any in Copernicus' time?



(Are you surprised that Copernicus doesn't have a telescope or a spy-glass? There weren't any in those days!

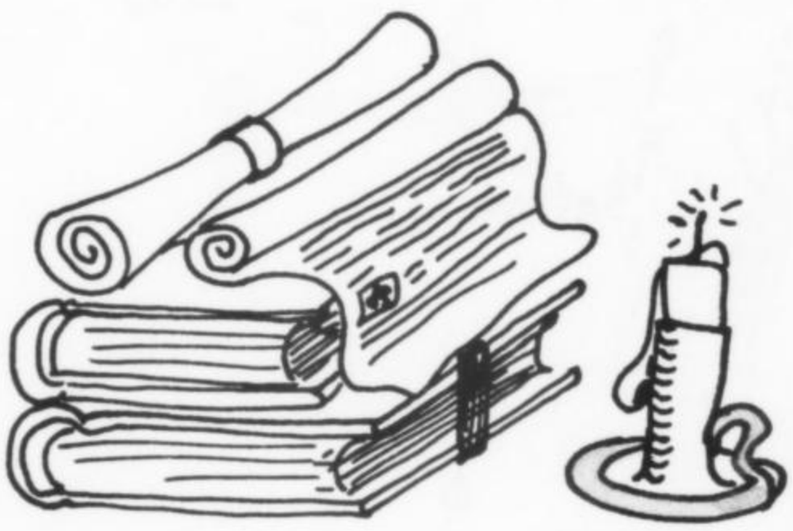
—There was plenty of protesting going on in Europe in those days. Copernicus himself wasn't an open rebel. Maybe he thought it better not to speak out about what he didn't understand too well. But Luther who lived at the same time as Copernicus disagreed with the way that the Roman Church had interpreted the Old and New Testaments. And he asked lots of

¿¿¿ QUESTIONS ???...

So astronomers had only their eyes to scan the skies!)

... All kinds of ? questions ?
? questions ? questions ?
? ? questions ?
They kept popping up everywhere!

It was clear that the world had not been created in 7 days... and that this account was more or less symbolic... So why stop there? At the same time, many ancient Greek and Hebrew manuscripts were beginning to be translated (into Latin!) and these books were being read... one came to know what Arab and Jewish scholars had written in the 10th and 11th centuries...

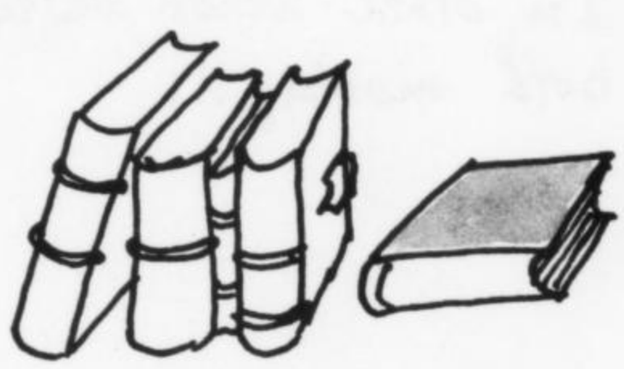


large quantities of books began rolling off the new printing presses so that everything that had been written could be read by everyone... And the number of books written was already beginning to pile up. This may have been the most important thing that happened in Copernicus' time: Knowledge was no longer LOCKED UP in very rare manuscripts, but was now within the reach of ALL THOSE who were prepared to make the effort to read those thick books...

Copernicus, in his tower, high above his cold little town beside the Baltic, read and read and read. Although he was not in "revolt" against the teachings of the Church, he nevertheless dared to ask himself certain questions... about the Heavens...

- Why didn't he look for the answers in his astronomy books? Or didn't he have any?

- Of course he did...

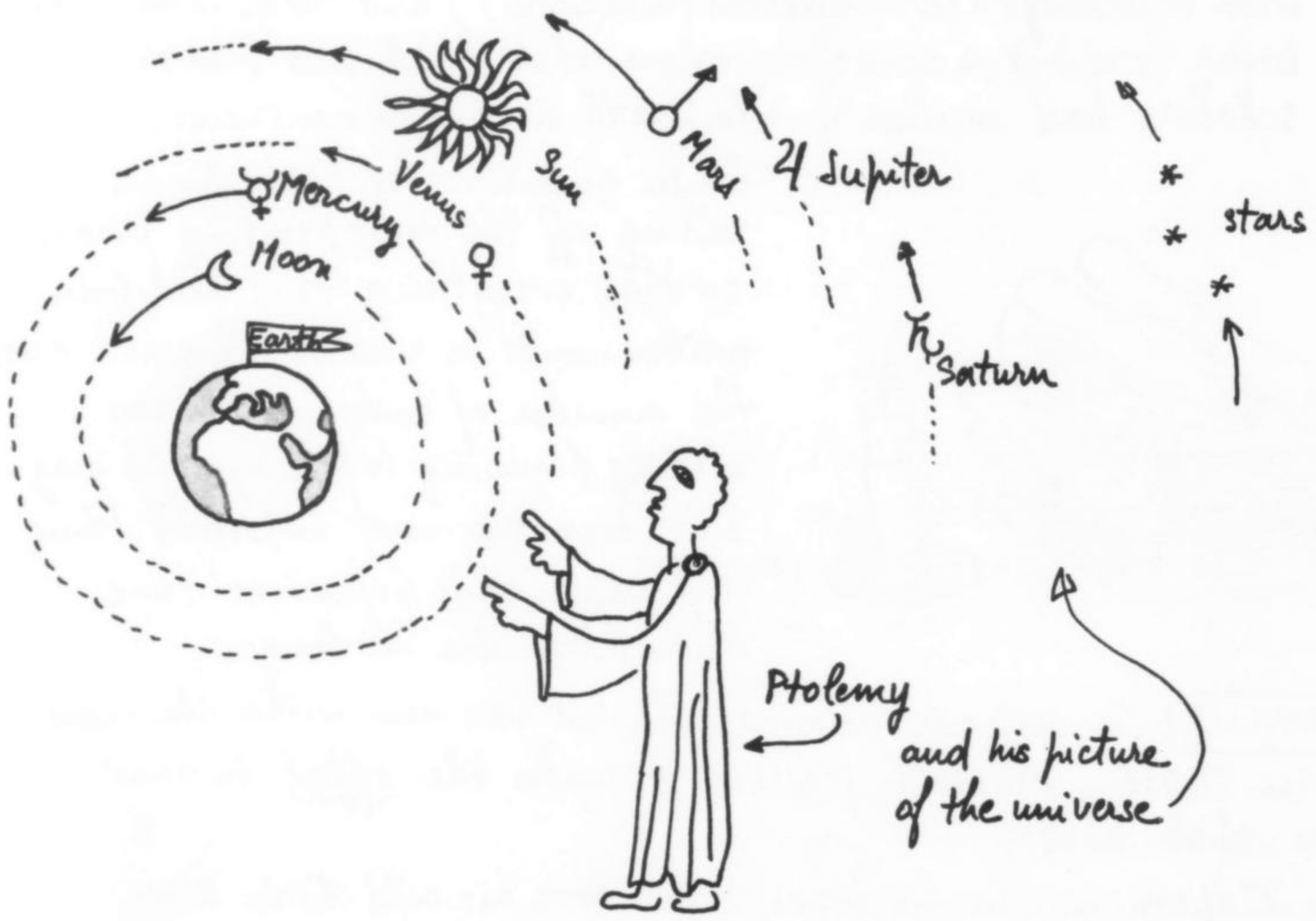


but....

... but he wasn't at all satisfied with what he read. Everybody's opinion was different and they all seemed to CONTRADICT each other.

In the time of the Ancient Greeks, Aristarchus of Samos said that the Earth and the planets revolved around the Sun; but Aristotle and Ptolemy said exactly... the OPPOSITE: the SUN moves around the EARTH, and so do the planets... The EARTH IS THE CENTRE OF THE UNIVERSE.

–But how do you know which is right?



– That's a good question, but it's not easy to answer. But watch this: Let's suppose we're dancing a waltz. Then I'm dancing around you and at the same time you're dancing around me. In other words we're both moving...

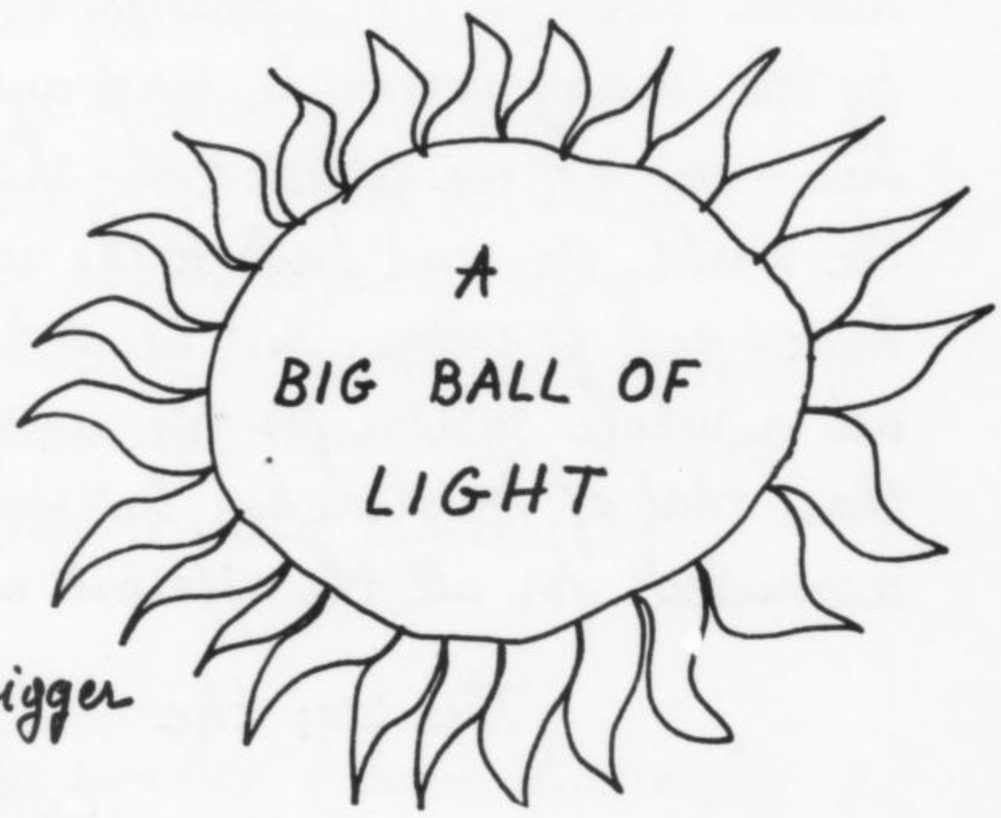
But...

... if I take a ball and swing it at the end of a string, the ball turns around me, not me around the ball! — the ball is little and I am big — and as you see I hardly move in relation to the floor of the room.

Now, early man may have thought that the Sun was only a little ball. But in the time of Copernicus, and before then, in the time of the Greeks, they knew better. Astronomers had carefully traced the movements of the heavenly bodies in the sky — planets, the Moon, the Sun and the stars. But they knew much more than that. The Ancients had measured the size of the Earth, the size of the Sun and the distance between them.

But that's another story.

They knew that the sun is



much bigger than

!

This was a very important discovery.

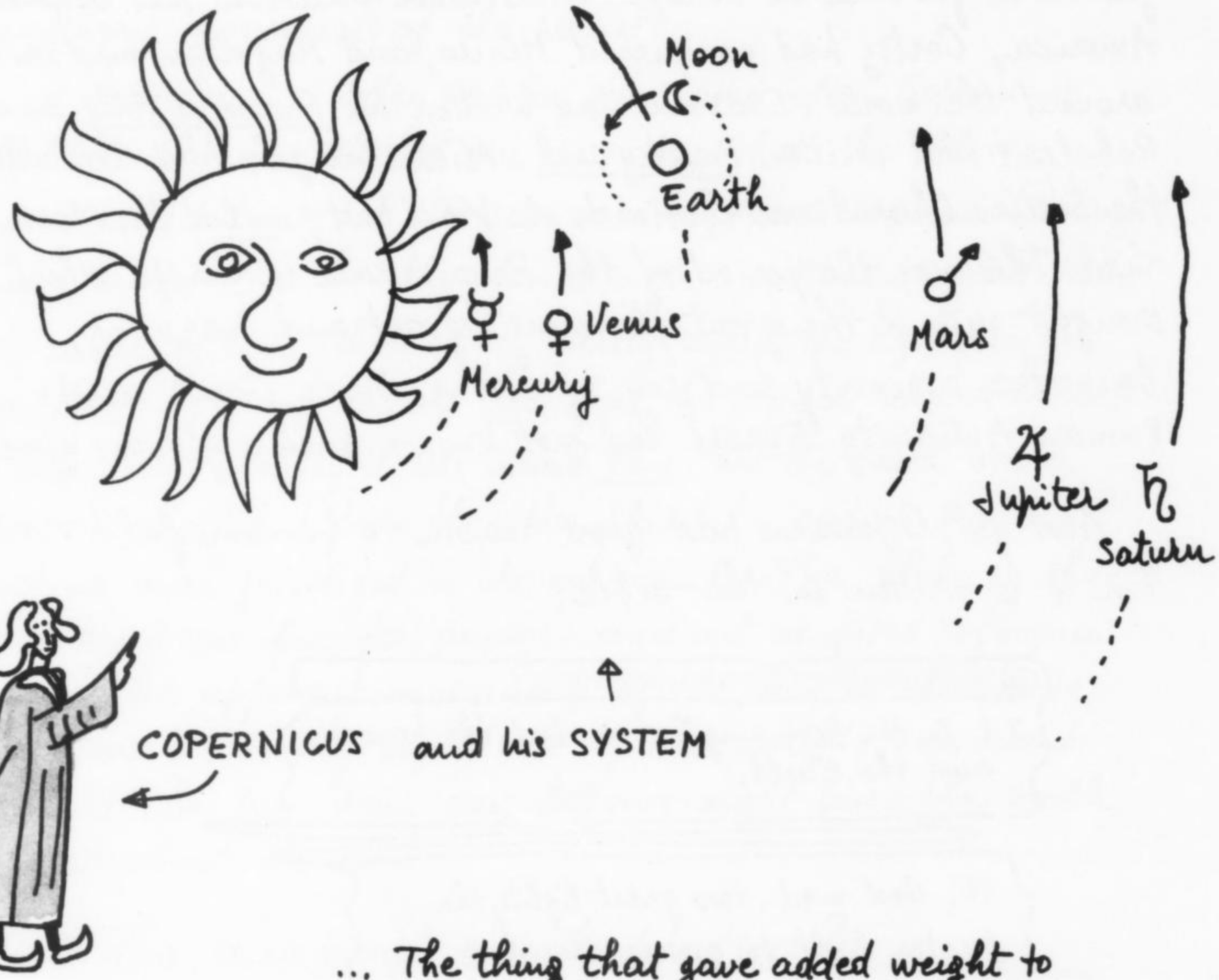
Another thing they knew was that certain planets such as Mercury and Venus, when viewed from the Earth, never seemed to stray very far from the Sun. They did not follow a regular, circular path around the Earth, and so it was more natural to link them with the Sun.

Of course Ptolemy's system wasn't as simple as I've drawn it. What he said was that the planets moved in circles and that the centre of each described a uniform circular movement around the Earth. In fact it was a very complicated system - but it did account for the apparent movements of all the planets. And it was much more elaborate than the mere idea put forward by Aristarchus of Samos who, though he was right, never spelled out or developed his idea, so that it was soon forgotten.

Between the time of Ptolemy and Copernicus many thinkers pondered these questions... Many persons point to the Middle Ages as a period of barbarism. But they're <u>wrong</u>. In fact it was just the opposite. Little by little a clearer picture emerged of the "systems of the Universe". But these important advances remained hidden away in the monasteries. Copernicus was certainly influenced by the many works he read and by his own conviction that the huge Sun - and not our little Earth - should logically be at the centre of the world. He went back to the ideas of Aristarchus, then totally buried and forgotten. But he did more than just that. He thought out a whole system for the movement of the planets, more complex than that of Aristarchus, but simpler than Ptolemy's which clearly accounted for all the apparent movements of the heavenly bodies.

This was the

COPERNICAN SYSTEM



COPERNICUS and his SYSTEM

... The thing that gave added weight to the Copernican system (one speaks of the "Copernican Revolution" as one does of the "French Revolution") was that in his time, as I mentioned earlier, a person's ideas and writings were quickly translated and printed and distributed over enormous distances. The Copernican Revolution, therefore, owes a huge debt to the translators and printers of those days.

Copernicus was a man who wouldn't have hurt a fly. He was so careful not to shock people that he held up the publication of his famous book until 1543, the year he died....

Between the day of his birth and the year of his death...

...what extraordinary changes the world had seen!

The Protestant Reformation of Luther and Calvin had gained a foothold in Europe. Christopher Columbus had discovered America, Cortez had conquered Mexico, and Magellan had sailed around the world. Erasmus had written his Praise of Folly and Rabelais had written Pantagruel. Michelangelo had decorated the Sistine Chapel and Leonardo da Vinci had painted the Mona Lisa. This was the period of the Renaissance in Europe which brought with it the great flowering of art and learning, boundless curiosity and joy of living. Since Greek and Roman Antiquity Europe had not known such a glorious epoch.

And yet, Copernicus had good reason to be careful! For it is written in the Bible:

I.1. In the beginning God created the heavens and the Earth.
16: God made two great lights, the greater light to govern the day...
VIII.22: As long as Earth lasts, sowing and reaping, cold and heat, summer and winter, day and night shall cease no more.
X.13: And the Sun stood still, and the Moon halted... The Sun stood still in the middle of the sky and delayed its setting for almost a whole day.

How could Joshua stop the Sun if it was the Earth that was moving? And if the Sun was created after the Earth, and if the death of the Earth meant the death of everything, then the Sun must be less important than the Earth....

But for the moment these points were rarely raised. It was believed that the Copernican system was neither <u>more true</u> nor <u>more false</u> than Ptolemy's system. Copernicus was merely <u>describing</u> the apparent movements of the planets...

But Kepler and later Galileo, who came after Copernicus, felt that the new SYSTEM was <u>more true</u> than the old one. It was indeed <u>true</u> that the SUN was BIG, MASSIVE and shining; it was indeed <u>true</u> that the planets were small and without their own source of light (didn't they merely reflect the light from the giant Sun?); it was indeed <u>true</u> that the planets rotated around the Sun. And finally it was indeed <u>true</u> that the Earth was a PLANET – no different from the other planets! – and no bigger and no more privileged in its movements. The stars on the other hand are far, far away... and act as fixed reference points. The apparent movement of the Sun in relation to the stars is simply explained by the Earth's movement around the Sun. And day follows night since the Earth rotates about its axis.

All this seems simple enough, doesn't it?

But in the time of Copernicus it wasn't at all easy to understand, – or to accept the idea that many of the lovely stories found in the sacred books of all religions weren't much help in astronomy; nor was it easy to admit that the distances to the stars were <u>enormous</u>, and that the Sun itself was just <u>one star among many others</u>, or that the Sun was really much bigger than the Earth!

So the Church of Rome put Copernicus' book

on the "Index".

This meant that no one was permitted to read, much less accept as fact, what Copernicus had written. And a scientist like Galileo later was forced to declare publicly that the Earth was motionless and that the Sun rotated around it — even though he believed the opposite....

Galileo

Today Galileo's famous remark "Yes, it does move!" (he was talking about the Earth) and everything associated with it seems far, far away indeed.

And yet you know, these are problems you really ought to think seriously about. Science still hasn't found the answers to many questions and there are many legends which masquerade as scientific fact — about the origin of life to mention only one example.

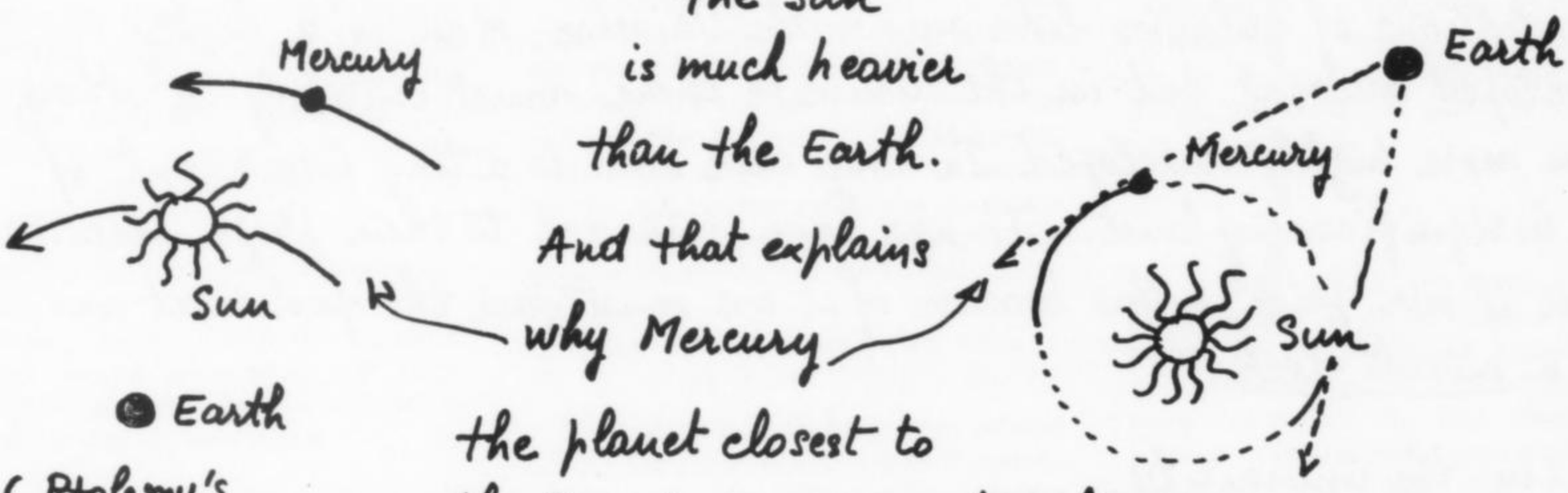
But one day science will come up with the right answers just as Copernicus, Kepler, Galileo and Newton did. And then we'll have to admit that the old legends
were lovely stories and perhaps nothing more.

— But Daddy, maybe the Church was right after all. What difference does it make whether it's the Sun that moves or the Earth? Isn't it the RELATIVE motion that really counts? Remember when you talked to me about "relativity" the other day?... I didn't understand everything you said then but I think I have a better picture now... Maybe Ptolemy's description of apparent motion wasn't as simple as Copernicus' was...

... but it was just as good. So when you said that one system was <u>truer</u> than the other, don't you think it's you who may be wrong?

— I'm afraid you haven't been listening properly. If the Solar system contained only the Earth and the Sun, then I agree that the two descriptions of their movement, with the Sun turning around the Earth and the Earth turning around the Sun, come to the same thing ...

But there are also the planets. They turn around the Sun, not around the Earth, simply because the Sun is much heavier than the Earth. And that explains why Mercury the planet closest to the Sun, is never seen far from the Sun itself.



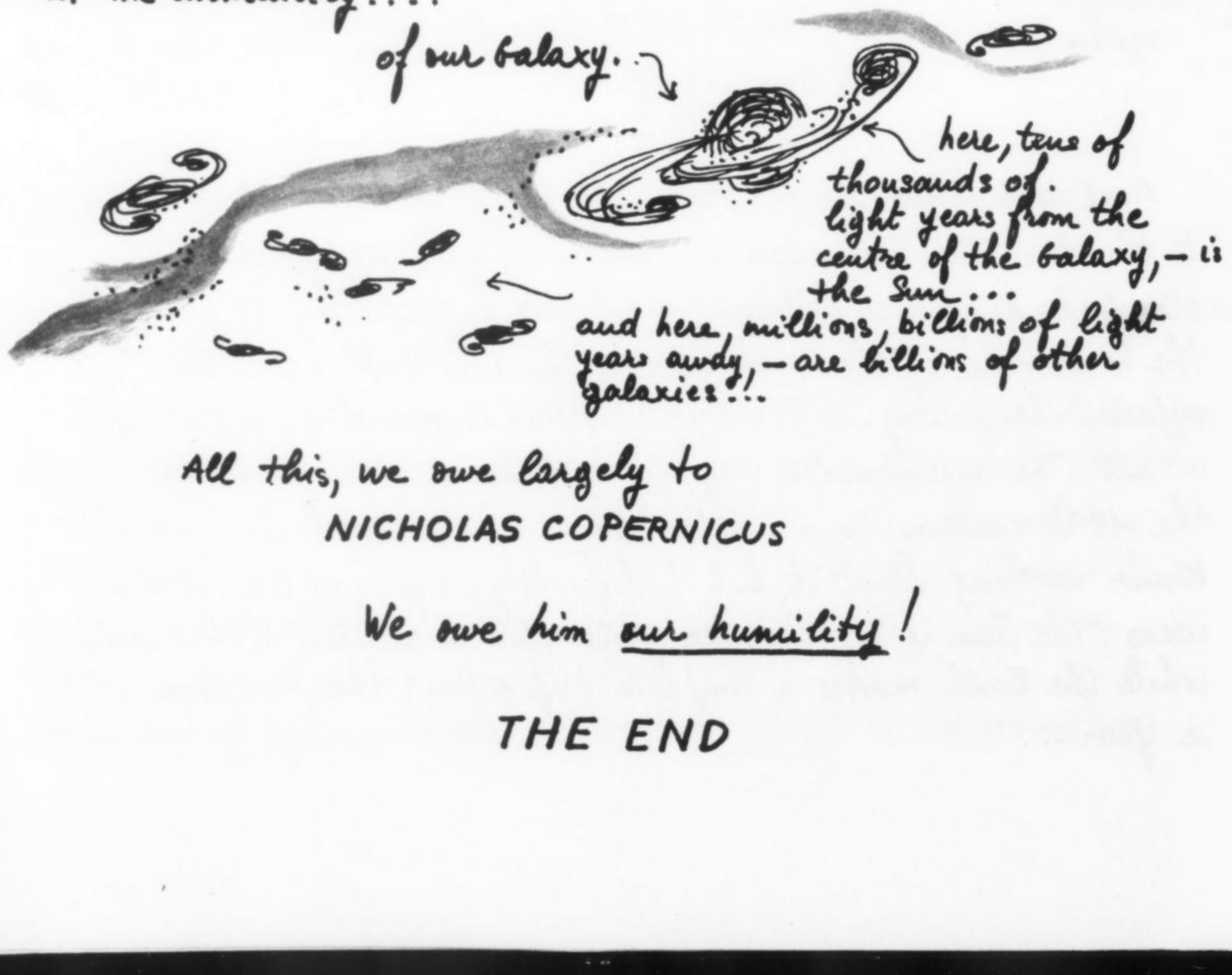
And then there are the stars. The Earth moves in relation to the stars. This motion can be seen every year. Every nearby star looks as if it is following a set path or trajectory. It is the movement of the Earth around the Sun that creates this apparent trajectory. In Ptolemy's system it cannot be explained at all. The movement is very tiny and wasn't observed until the 19Th century by an astronomer named Bessel. Copernicus knew nothing about it, but it definitely confirmed Copernicus' ideas. The Sun is more or less motionless in relation to the stars while the Earth makes a complete trip around the Sun once a year ...

– Daddy, did Copernicus ever get the Nobel Prize?

– No, I'm afraid not. First of all there was no Nobel Prize in his day, and second, no Nobel Prize for astronomy or geometry exists even today. Copernicus wasn't a physicist. He could DESCRIBE the movement of the planets... but he didn't know what CAUSED them (it was Kepler and especially Newton who worked that out)... But the name of Copernicus will live forever because ever since his book appeared we know that THE EARTH IS NOT THE CENTRE OF THE UNIVERSE, and because this fundamental discovery helped us to get rid of the idea that MAN, too, was the centre of the universe...

The Earth revolves around the Sun, – the Sun is just an ordinary star amongst the billions of stars that make up our Galaxy – and there are billions of galaxies like ours in the Universe. Man is a highly developed animal but in the Universe there must certainly be others, even more highly developed. In any case man is a tiny inhabitant of an insignificant planet... Things have returned to their proper place... Even if our pride suffers because of it we must face the fact that we are a minute speck

in the immensity....


of our Galaxy.
here, tens of thousands of light years from the centre of the Galaxy, – is the Sun...
and here, millions, billions of light years away, – are billions of other galaxies!!..

All this, we owe largely to
NICHOLAS COPERNICUS

We owe him our humility!

THE END

Imp. GEORGES LANG, PARIS. — Dépôt légal C 1 — Mars 1973 — IMPRIMÉ EN FRANCE (Printed in France)

(Continued from page 8)

nicus was faced with an enormous scientific task: to define and expound the heliocentric order of the universe in a work as wide-ranging and exhaustive as Ptolemy's *Amalgest*. Copernicus was to devote the rest of his life to this undertaking.

Without going into detail upon Nicholas Copernicus' duties as a member of the Chapter of Warmia, we should however note the fact that when the opening chapters of the great astronomer's memorable treatise were written, he was also exercising—and highly efficiently—numerous time-absorbing administrative, economic and political functions.

FROM 1516 to 1519, Copernicus lived in Olsztyn, where he managed the property of the Chapter. In spite of these activities he in no way neglected his astronomy, and the ingenious observation apparatus built by Copernicus himself can still be seen at Olsztyn castle, which is now a museum.

After the death of Lucas Watzenrode, Warmia went through extremely difficult times, during which the Teutonic Knights waged undeclared war upon the region, plaguing the diocesan lands with their armed incursions.

Olsztyn was in close proximity to the frontier of the monastic State, and when in 1520 war again broke out between Poland and the Teutonic Order, Copernicus returned there to organize the defence of the fortress against the impending siege. When the subsequent peace treaty was concluded in 1521, he was able to go back to Frombork.

There he continued his opposition to the Teutonic Knights on a different level: the battle-ground of economics. The fact was that the Teutonic Order was striking false coins, and thus causing the disruption of the Pomeranian currency market. After a number of interventions on this matter, Copernicus published in 1526 his *Treatise on Currency*, in which he explained the mechanism according to which "bad money drives out good".

The formulation of this principle, known as the Gresham-Copernicus Law, (it was also expounded by a 16th-century English merchant, Sir Thomas Gresham) is by no means the great astronomer's sole claim to fame in the field of political economy. To Copernicus, "good" money, or currency which consistently maintains its full value, is as much the result as the condition of "enrichment", or in other words, of a healthy economy based upon the work of "excellent workers" and a well-organized system of exchange.

Copernicus gives us a highly accurate definition of the true stimulants to economic activity—a definition which has little to do with the moral imperatives of plain hard work expounded by the scholastic philosophers.

During the years following his return from Olsztyn to Frombork, Copernicus crystallized the formulation of the plan for his major work, later known under the title *De revolutionibus orbium coelestium*, and written in six sections or books, which was to be the great Polish astronomer's immortal contribution to world scientific literature.

The revolutionary element of Copernicus' work lies in his elaboration of entirely new cosmological principles, by which he stripped the earth of its role as the Centre of the Universe, discovered its daily and annual movements, and redetermined the planetary system with the predominant position now attributed to the sun. The treatise was put into its final form in the early 1530s, but another ten years were to go by before it was actually printed.

The publication of the printed edition of the *De revolutionibus* has a history of its own. In 1539, Georg Joachim Rheticus, a young professor of astronomy from Wittenburg, arrived in Warmia, drawn by the rumours in Europe about the astounding work being done by the solitary Frombork astronomer.

It was thanks to Rheticus and Tiedman Giese, Bishop of Chelmno, humanist and faithful friend of the astronomer, that Copernicus eventually allowed himself to be persuaded to publish his work, and finally prepared a copy of the treatise for printing.

Rheticus himself published a volume entitled *De Libris Revolutionum D. Doctoris Nicolai Copernici Narratio Prima* (Gdansk, 1540), which heralded the appearance of the great work itself. Two years later, Rheticus published a lengthy extract from Copernicus' treatise, dealing with spherical trigonometry.

Science historians will long be fascinated by all the events surrounding the printing of *De revolutionibus* in Nuremberg, and the part played by the astronomer Johannes Schöner and, especially, the theologian Andreas Ossiander, who both verified the text.

The prudent anonymous foreword inserted by the publishers when printing was already under way, which puts Copernicus' theory forward as a purely formal hypothesis, contrasts sharply with the magnificent letter of dedication addressed by Copernicus to Pope Paul III, which is an admirable eulogy upon astronomy and its cognitive values.

Tradition has it that the first copy of the work, printed in Nuremberg, reached Copernicus only on May 24, 1543, the very day of his death at the end of a long illness.

More than eighteen centuries lie between Copernicus and Aristotle, the "Prince of Philosophers" of ancient times, and for 13 centuries, Ptolemy's *Almagest* had invariably been accepted as the perfect representation of the system of the Universe. The mere four hundred years or so since the beginning of the revolution in modern thinking set in motion by Copernicus has to be compared with a period of almost two thousand years of intellectual stagnation.

DURING the first century following the death of Copernicus the names of the illustrious pioneers of our own knowledge of the universe were recorded in the annals of science. Galileo and Kepler both drew their inspiration from the work of Copernicus, and it culminated in the appearance of Newton's *Principles*.

In the dedication of *De revolutionibus* Copernicus wrote: "If, however, there be guileful men who, although they know nothing of mathematics, nonetheless allow themselves to pass judgement upon such matters, and who, on the basis of a cunningly distorted interpretation of a passage of the Scriptures, dare to attack and condemn my work, I dismiss them so entirely as to despise their judgement as blindly presumptuous."

Copernicus had the courage to expound his innovative ideas in a scientific work of profound maturity and to contradict the traditional authority of the Ancients. This is why today the world is celebrating the quincentenary of his birth.

The object of our admiration is not only the creator of the heliocentric system: to an even greater extent, Copernicus should be remembered as the scholar who opened the way for the long procession of the creators of modern science. ■

Jerzy Bukowski

The great cultural revolution of the Renaissance

From Poland across Europe to Italy a whole world in intellectual ferment

by Paolo Rossi

COPERNICUS was nineteen year old when Christopher Columbus set foot on the American continent in 1492. His life covers the central period of the Renaissance and the Protestant Reformation, an era marked by the wonder of Renaissance art and by the division of Europe into two religious camps.

It was a period that witnessed the wars between France and the Holy

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PAOLO ROSSI, *professor of the History of Philosophy at the University of Florence, is a noted authority on the history of science in the 16th century. He has written many books on this period, including* Aspetti della Rivoluzione Scientifica *(Aspects of the Scientific Revolution) and a biography of Francis Bacon, also published in English editions (Routledge and Kegan Paul, London, and University of Chicago Press, 1968). Author of* I Filosofi e le Macchine *(Philosophers and Machines) also published in English (Harper and Row, N.Y., 1969), he contributed to the preparation of Italian editions of works by Bacon, Vico and Diderot.*

Photo Copernicus Museum, Rome

Astronomy class for Leonardo, Michelangelo and the Pope

After completing his studies at the University of Bologna (Italy) Copernicus went to Rome where, in the year 1500, he gave a course of lectures on mathematics and astronomy, in which he is said to have drawn attention to the faults in Ptolemy's conception of the universe. In this 19th century painting, Wojciech Gerson, a Polish artist, shows Copernicus lecturing in the presence of Pope Alexander VI. The scene is imaginary, but all the persons depicted are known to have been at the Papal court of that time. In addition to Pope Alexander (1), the distinguished audience includes Leonardo da Vinci (2), Michelangelo (3), Caesar Borgia (4), the painter Pietro Perugino (5), the architect Donato Bramante (6) and Baldassare Castiglione, diplomat and author (7).

Roman Empire and a series of economic and social revolutions that followed geographical discoveries and epic voyages of exploration. It saw the start of the break up of the European feudal system and the consolidation of the great European States.

Copernicus was a contemporary of the humanist Erasmus of Rotterdam and the reformer Luther, of King Henry VIII of England, under whom the English Church gained its independence from Rome, of Emperor Charles V, of Michelangelo and Leonardo da Vinci, of the Swiss astrologer and doctor Paracelcus and of Machiavelli the great Italian theoretician of political science.

The cultural world around Copernicus was in ferment and thirsting for new things. The Protestant Reformation claimed the right to interpret the scriptures freely and was a determinant factor in the breakaway from the rigid intellectual discipline that was a feature of medieval civilization. The artists and scientists of his time were also fired with the desire for complete renewal and an open-minded approach to nature.

Leonardo da Vinci (1452-1519) proclaimed the need for an honest study of the reality of nature enabling phenomena to be accurately described and measured. Research into nature, he declared, should use the tools of mathematics and the analytical capacity of human vision and should, above all, put an end to the simple repetition of already prevalent ideas.

Those who base their assertions on quotations from the authorities of the past and on what is written in the old books, wrote Leonardo, "are not using their imagination but their memory."

No credence should be given to those philosophers "whose arguments are not confirmed by experiment." Leonardo invoked "experiment" and "reason" at one and the same time; he preached the need to weld together experimental contact with the world and abstract or mathematical theories opening the door to the innermost secrets of the universe.

Contesting the culture of university professors and "men of letters", Leonardo described himself as an "unlettered man". Typical of his thought —and the thought of his time—was an insatiable curiosity with regard to nature. Why were shells found on mountains? How was it that birds could fly? What caused the wind? What were the mechanics of walking in men and in animals?

These were the origins, apart from his activity as an artist, of Leonardo's innumerable plans for machines, his anatomical research, and his pages of reflections on science and on what science should be about.

Violent disagreement with the followers of Aristotle, a burning passion for knowledge of the "mysteries of the sky and the secrets of nature", and an encyclopaedic mentality thirsting for information about all branches of knowledge, also marked some of the most famous practitioners of the so-called "natural magic" of the Renaissance: the Italian Girolamo Cardano (1501-1576), the Swiss Paracelcus (1493-1541), the German Heinrich Cornelius Agrippa (1486-1534) and the Italian Gian Battista della Porta (1535-1615).

The "revival of magic", with which these doctors and astrologers were concerned, was above all a study of natural effects. They felt that it would give man dominion of the world, and that man could only achieve this result by becoming the "minister" or servant of nature.

The miracles of magic, wrote Cornelius Agrippa in his work *De vanitate scientiarum.* (On the Vanity of Science) are very different from those described by religions. In the latter there is violation of the laws of nature whereas the miracles of magic are the result of

CONTINUED NEXT PAGE

Medieval beliefs and the new thinking

operations carried out by man on nature.

These miracles (in the etymological sense of the Latin word *miracula*) are no more than "things which ought to arouse wonder", and primarily consist in the ability to speed up the processes of nature: by shortening the time that nature needs to ripen fruit on the trees, for example, or to modify the rhythm of the seasons by farming techniques.

Before going further it might be useful to explain some of the fundamental aspects of the age in which Copernicus lived.

The distinction between magic and science, so obvious today, was not by any means evident in the first half of the sixteenth century. The thirst for experiment, the study of nature and the observation of phenomena were exalted and proclaimed at that time as part of a vision of the world which is very different from that held in the next century by Francis Bacon, René Descartes and Galileo.

The founders of modern science (and of modern philosophy) waged a bitter battle (as did Bacon) against the "magic" mentality of the preceding century or regarded that mentality (as did Descartes and Galileo) as an outdated way of thinking with which a natural philosopher or a scientist should not concern himself. Copernicus lived in an age in which the distinction between magic and science was not as clearcut as it came to be later.

The rebellion against traditional thinking and above all against Aristotelian philosophy was a key theme of the Renaissance. The French philosopher and grammarian, Pierre de La Ramée (Petrus Ramus) claimed to be able to demonstrate the falsity of *all* Aristotle's doctrines.

This rejection of tradition and this general desire for innovation also implied a breakaway by the new culture from the world of the universities in which Aristotelian philosophy was still dominant. A majority of scientists in the 16th century studied in the universities and in many cases taught in them but there is no doubt that the liveliest discussion—that concerning scientific and cultural innovation—no longer took place within the walls of the universities as had happened in the Middle Ages.

The universities, in the second half of the 16th century and during the next century, lacked the ability for the new thinking necessary in times of rapid intellectual development. The new Copernican astronomy was to be very slow in conquering the academic world. The old Ptolemaic astronomy continued to be taught for more than a century after the publication of *De revolutionibus*, and Galileo himself gave courses in Ptolemaic astronomy.

During the years in which a new method was evolved based on the recently-discovered texts of Archimedes, Euclid was still read in the universities. Mondino's work on anatomy (which was typically medieval in its approach) long continued to be the medical students' textbook even after the appearance of the first modern book on anatomy, published by Andrea Vesalius in 1543.

From this situation stemmed the need for the renovation of institutions, closely tied up with the need for new methods of acquiring and transmitting learning. The groups of student followers of a single master, the academies, and the scientific societies that came into being in Europe in the 16th and 17th centuries tended to meet these new requirements.

Copernicus' great work triggered off the scientific revolution which came to full flower in the writings of Newton and from which many fundamental aspects of the modern world are derived. From this revolution were born new forms of physics, astronomy and medicine, totally different from those of the ancient Greeks and Romans.

The contribution made by Copernicus to the scientific revolution concerns astronomy, but we should not regard Copernicus as an astronomer in the technical and modern sense of the word. Copernicus was a man imbued with the culture of his time and his training was that of a humanist (in the meaning this term had in his day).

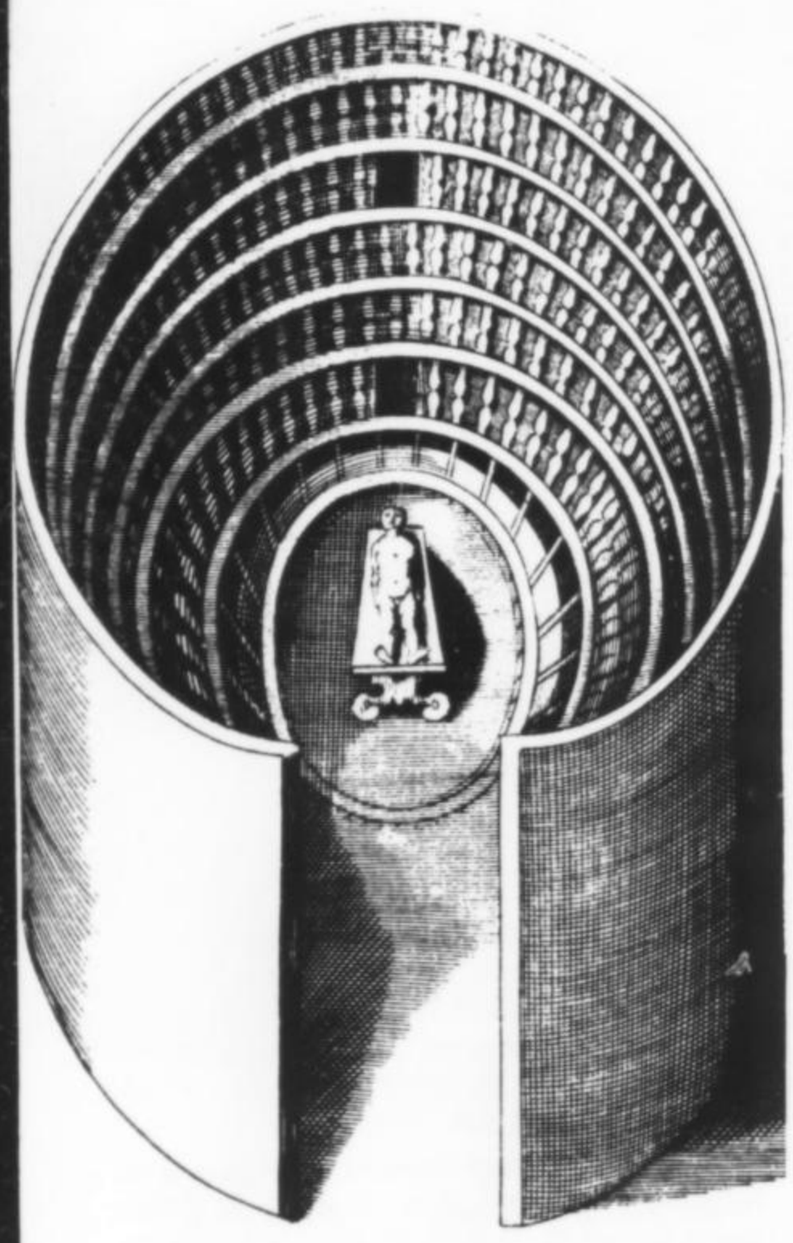
He was learned in law, medicine, economics, and administration. In the universities of Cracow, Bologna, Padua and Ferrara, he studied in turn mathematics, astronomy, law, medicine and philosophy. In Italy he learned Greek and read Plato. One of his teachers, the astronomer Domenico Maria da Novara, was a follower of the Platonic and Pythagorean philosophy that dominated Italian Renaissance culture.

As with many humanists, Copernicus presented his astronomical discoveries and his new world system, not in the form of a reasoned refutation of traditional theories, but as a revival of Pythagorean theories. He presented his theory to the reader as being intimately bound up with a contemplation of the world looked upon as a revelation or manifestation of God.

He set out his discoveries in a religious context. The sun, lord and king of the visible world was a symbol of God.

This glorification of the sun and the repeated references to Pythagoras found in *De revolutionibus* link the thinking of Copernicus with one of the main currents of Renaissance philosophy.

In 1462 the Italian Marsilio Ficino had begun his translation of Plato's

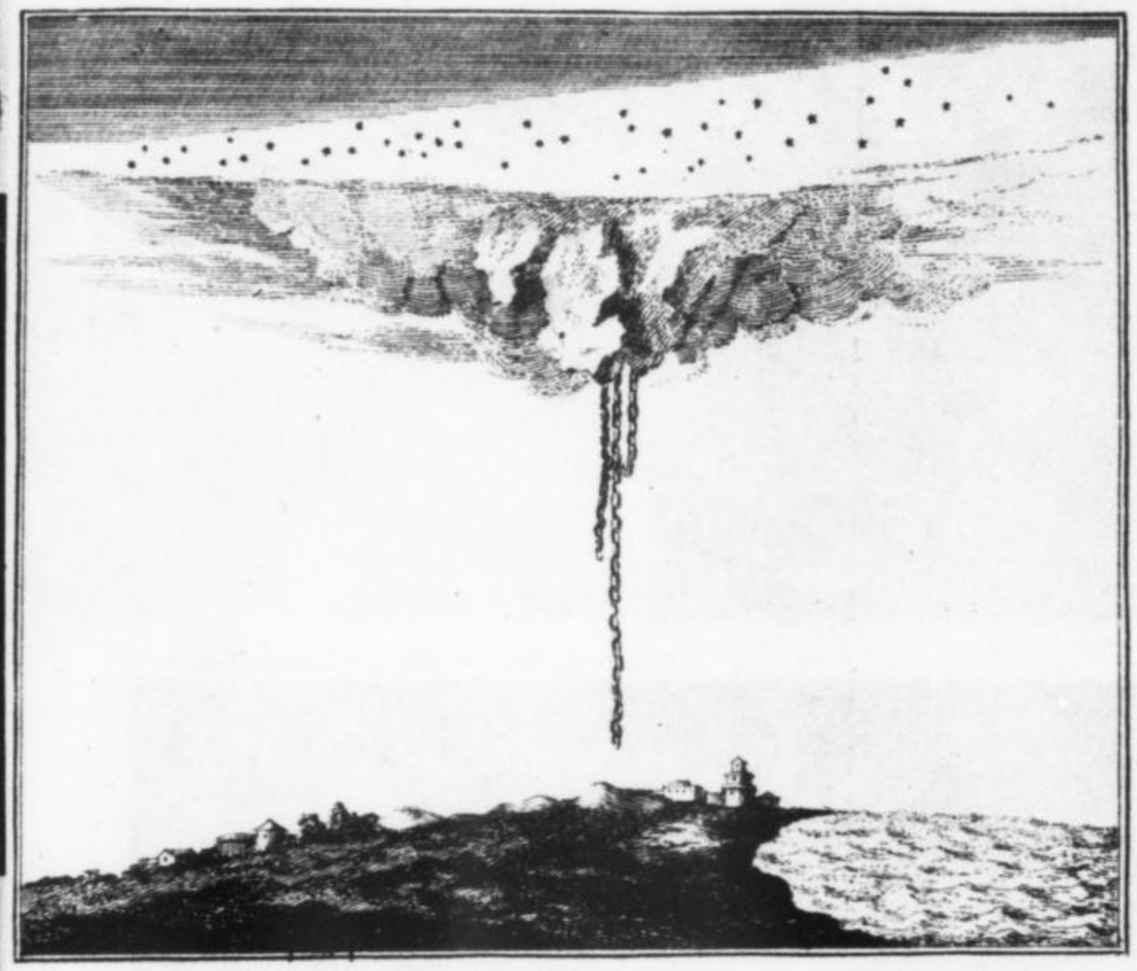


For a long period of his life Copernicus was more highly esteemed as a doctor than as an astronomer. From 1501 to 1503 he studied medicine at the University of Padua, the foremost centre of medical learning of the day. New approaches were being made to the study of anatomy but research on human cadavers had only recently been authorized and Copernicus' medical studies were quite conventional. The anatomy amphitheatre at Padua, shown in the engraving above, was not erected until 1594, more than 50 years after the death of Copernicus.

Photo © from "Inventeurs et Découvertes", Editions Hachette, Paris

Dating back to the 10th century B.C., this Egyptian papyrus painting (above) shows the speckled body of the sky goddess Nut pushed upwards by Shu, the god of air, to form the vault of the heavens, the speckles of her body becoming the stars. Nut was married to her brother, the earth god Geb, but the match was opposed by the great god Re, ruler of the world, who ordered their father Shu to raise Nut away from Geb, thus separating the heavens from the earth.

Photo Cairo Museum © Hassia, Paris



According to a learned paper published in 1726 by an eminent French scholar of Greek literature, Jean Boivin, the Greek poet Homer imagined that Mount Olympus, the home of the gods, was a mountain which rested on the sky and whose summit pointed down towards earth. In a passage from the "Iliad", illustrated by the engraving, left, Zeus speaks of suspending the earth in the air from a golden chain attached to the highest point of Mount Olympus.

Photo © Bibliothèque Nationale, Paris

Dialogues. Even before working on Plato he had translated into Latin the much famed *Corpus hermeticum*—a collection of the writings of Greek authors living between the third and first centuries before Christ.

These writings, a mixture of Platonic and Stoic themes and showing the influence of Hebrew and Persian philosophy, were attributed by Ficino to a mythical Egyptian being—the god Thoth—identified by the Greeks as their god Hermes and sometimes known as Trismegistos (thrice great).

In Platonic philosophy Marsilio Ficino saw a doctrine of the eternal religious revelation, made manifest in every age and finding its highest form of expression in Hebraism and Christianity.

This religious philosophy, stated Ficino, "was born with Zoroaster among the Persians and with Hermes among the Egyptians, nurtured with Orpheus among the Thracians, developed with Pythagoras among the Greeks and the Italiotes and reached its zenith in Athens with Plato". To Ficino and to the Italian Renaissance Platonists, philosophy and religion were not two separate things: great philosophical thought and the sacred writings of the various religions all converged towards the same result.

In a passage from *De revolutionibus* concerning the central position of the sun, Copernicus refers explicitly to the name of Hermes Trismegistos. His new astronomic doctrine first saw the light of day in a philosophic and religious context that was clearly neo-Platonic in inspiration, and he used a quotation from a famous work in which Hermes had described the sun cult of the ancient Egyptians.

For us Copernicus' book has become a point of departure, and almost the symbol of the intellectual revolution from which modern science has sprung. As we have seen, this book was written in an age which hungered for new things, which was prepared to question traditional beliefs, and which struggled in the difficulties arising from the gap between scientific and scholastic institutions and the real progress of science.

It was not by chance that all this happened, and in this sense the book of Copernicus is one of the characteristic expressions of the dawn of modern culture. And yet Copernicus, deeply imbued with neo-Platonic philosophy, preferred to present his new picture of the world as a revival of old doctrines rather than as a revolutionary innovation.

He was a timid and cautious man. Perhaps his interest in the sun—which was one of the main topics of neo-Platonic philosophy of the 16th century—spurred him to his astronomic research aimed at proving the sun to be the centre of the universe. Perhaps also he was endeavouring to make what was new in his astronomy acceptable to his contemporaries by setting it in a philosophical context familiar to the intellectuals of his time.

At all events, it is clear that Copernicus used to the full two great lessons of 16th century thought: that the discovery of geometrical and arithmetical regularity in nature is essential for the understanding of the world; and that the truths handed down from antiquity should be examined critically and, if necessary, revised. ■

Instruments for stargazers

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On these pages we show a number of astronomical instruments used in Copernicus' day. The design of such devices had remained basically unchanged since ancient times and astronomers often made observations with instruments constructed centuries earlier. The Arab astrolabe in copper (above), dating from 1054 was being used at the Jagiellonian University (Poland) when Copernicus was a student there. The astrolabe, used for taking altitudes and observing the sun and the stars, is said to have been invented by the Greek astronomer Hipparchus in the 2nd century A.D. Right, a 15th century armillary sphere, also probably used by Copernicus at the Jagiellonian University. Armillary spheres were astronomical models of the heavens, usually with nine rings representing the equator, horizon, meridian, tropics, polar circles, zodiac and an ecliptic hoop (compare with Ptolemy's less elaborate armillary sphere on page 28). Above right, a miniature from a 13th century psalter belonging to Blanche of Castile, mother of St. Louis, king of France. Seated between two assistants, an astronomer takes sights on a star with an astrolabe. Above left, the famous, gilt-bronze "Jagiellonian Globe", dating from 1510, on which are engraved the outlines of Europe, Africa and South America; beside the latter is the inscription "Terra de Brazil, Mondus Novus, Terra Sanctae Crucis". North America is shown as a series of islands. Left, a 16th century, gilt-bronze theodolite, a surveying instrument sometimes used by astronomers for calculating latitudes. A compass can be seen in the centre of the base of the instrument.

Photo © Nina Smolarz, "Poland" Warsaw

Copernicus, Galileo and Giordano Bruno

Three thinkers who dared to challenge the powerful forces of tradition

by Vincenzo Cappelletti

Photo © Kazimierz Czapinski, "Poland", Warsaw

To commemorate the achievement of Copernicus, the authorities of Torun, birthplace of the great astronomer, organized a nationwide design contest for a monument to be raised in the town (see also page 4). Here are two of the 30 or so projects expressing the Copernican conception of the solar system submitted by Polish sculptors. Far left, "Dawn" by Bronislaw Chromy; left, "Nicholas Copernicus" by Gustaw Zemla.

IN his famous treatise *Metaphysics*, Aristotle says that, among the mathematical sciences, astronomy is closest to philosophy since it deals with the nature of the stars, and these are eternal even though perceptible to our senses. In the order of things, as seen by Aristotle, God was thought of thought and Prime Mover of the eternal heavens.

The old, pre-Christian world shrank from pursuing this line of philosophical thought to its ultimate conclusion which would have led to the separation of God from nature. In some way nature had to be cloaked in divinity so that metaphysics and religion could be reconciled with the evidence of the senses.

VINCENZO CAPPELLETTI *is professor of the History of Science at the University of Rome. Director-General of the "Enciclopedia Italiana", and director of the review "Il Veltro", he is author of many books on the history of biology, physics and psychology. His publications on these subjects include "Entelechia" (1965), "Helmholtz" (1967), "S. Weil - Sulla Scienza" (1971) and "Metapsicologia di Freud" (1972).*

Before Copernicus, metaphysics and the phenomena experienced by the senses were in agreement on one point—the earth was fixed in the cosmos and it was the stars that moved. They moved in a circular path, that is to say with a movement in which beginning and end were ever joined, thus reproducing eternity in time.

The important thing for the Ancients, in the platonists' famous phrase, was "to preserve the phenomena" (to fit observed facts into theory), and this seemed a better way of "preserving" them than any other.

On this point, in Galileo's *Dialogue of the Two Chief World Systems*, Simplicio makes an enlightening comment: "The Copernican doctrine means denying the senses and above all the sensations. This must be the case if, though we are aware of the gentlest breeze, we cannot feel the blast of a perpetual wind reaching us at a speed of over 2,559 miles an hour, for this is the distance that the centre of the earth covers in one hour along the circumference of the great orb, according to Copernicus' meticulous calculations."

Many things seemed, and would seem, more simple if the immobility of the heavenly body on which man lives were to be accepted. It was not until Galileo and his intuition of the notion of mass that this assertion could be disproved.

Aristotelian thinking had succeeded in separating the destructible, imperfect earth, from the indestructible purity of the heavens in which it set God the Mover of the world.

In spite of St. Paul and St. Augustine, early Christian thinkers found themselves in the blind alley of naturalistic theology. The fathers of the Syriac church formulated a literal interpretation of Genesis (the creation of the world in seven days) which was in many respects at variance with the Greek scientific tradition; Cosmas Indicopleustes (a little-known Greek thinker who visited India) attempted to replace pagan topography and cosmology by "a Christian topography of the Universe". For Cosmas, the earth was not in the centre of the universe but at the lowest point of the solar system; a rectan-

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The sphere, the most perfect shape of all...

gular plane covered by the vault of the firmament.

The real interest in all this, however, lies not in the mistake itself (a mistake which was to cause Copernicus serious difficulties and bring Galileo before his judges), but the criterion on which it was based—that science was subservient to religion and metaphysics.

Copernicus himself believed in an order, a perfection of the world which had to be preserved. And it is in this respect, in spite of the majestic grandeur of his work which is due to the unswerving rationality of his system, that Copernicus still seems to us to belong to antiquity. In the dedication of *De revolutionibus* (On the Revolutions) to Pope Paul III, he maintains that in accepting the theory of eccentrics and epicycles the champions of geocentrism have compromised "the shape of the world and the undoubted symmetry of its parts".

The first chapter of *De revolutionibus* opens with a further profession of faith in the perfect structure of nature: "We must first observe that the world is spherical both because this shape is the most perfect of all, forming an unbroken totality, and because this shape has the greatest capacity and therefore is the most suitable for that which is required to embrace and conserve all things".

The central position of the earth was finally accepted by the Christians of the Middle Ages as it had been by pagan antiquity. Aristotle and the Bible, the Ptolemaic universe and the universe revealed by the Bible could both agree with Thomas Aquinas that reason and revelation were not self-contradictory.

Whether as God's pedestal, according to Cosmas Indicopleustes, the part of the world opposite to the firmament-paradise, according to Honorius d'Autun, or the seat of hell, as Dante saw it, the earth was given a precise position in the cosmos by a Christianity as yet not fully aware of the spiritual revolution brought about by the Gospels.

In fact, naturalistic metaphysics had deformed the facts of experience, or rather it had glossed over the contradictory aspects of observation. In its endeavour to reconcile the world and God it had omitted to reconcile the world with the mind, with human thought. In a marvellous passage in *De revolutionibus*, Copernicus speaks of "thought blown hither and thither".

The original purity of the system of spheres all with the same centre, conceived by the Greek mathematician Eudoxus of Cnidus early in the 4th century B.C., had undergone gradual decay, interrupted by moments of true inventive genius, to culminate in the tardy synthesis of Claudius Ptolemy's *Almagest* in the 2nd century A.D. Although the evidence of the senses appeared to support the cause of geocentric astronomy, it also contained elements which provided a basis for the formulation of various other theories.

In Galileo's *Dialogue*, Simplicio asks Salviati: "But from what do you argue that it is not the earth but the sun which is the centre of the movements of the planets?" And Salviati replies: "This is a matter of observations which are wholly obvious and therefore necessarily conclusive; and of these observations, the most telling, which allows us to remove the earth from the centre and put the sun in its place, is the fact that all these planets are sometimes close to the earth and sometimes farther away. And these variations in distance are so great that Venus, for example, is six times farther away from us when at her farthest point than at her closest point, and that Mars is eight times farther away. You can clearly see that Aristotle was somewhat mistaken in thinking that these planets were always at the same distance from the earth."

As well as the geocentric principle, the ancient world had known the heliocentric principle devised in the first half of the 3rd century B.C. by Aristarchus of Samos. Archimedes, through whom we know of Aristachus' heliocentric theory, put forward some objections but was not unduly shocked by it.

Photo © Erich Müller, Kassel - from "City of the Stargazers" by Kenneth Heuer, Charles Scribner's Sons, New York

Copernicus makes many references to the heliocentrism of the ancients as if needing the hallowed authority of the classical era as support to his own revolutionary propositions. In *De revolutionibus* he demands the same "freedom to imagine" that Aristarchus and others had allowed themselves in their explanations of astronomical phenomena.

And Copernicus allowed himself to be carried away by the potency of the solar symbol, stating that the sun—veritable light of the world—was more worthy than the earth to occupy the centre of the universe. Thus he too ended by referring to a divinified concept of nature such as that which had led the astronomy of antiquity into a blind alley.

Yet Copernicus invoked the laws of reason and not those of a divinified nature when building his magnificent theoretical construction, based in part on original observation, but mainly on already available data. In Copernicus, faith in reason takes on almost mystic overtones. He even goes so far as to imagine a non-existent letter from a Pythagorean in which truth is regarded as a religious secret to be communicated only to the privileged few.

Giordano Bruno in his writings, forty years after *De revolutionibus*, showed the fullest understanding of the Copernican revolution. Copernicus had restored the dominion of reason over the senses and opened the path to the affirmation of the infinite and the freedom of thought of modern man. In Aristotelian and Ptolemaic astronomy Bruno saw a codification of the universe based on partial data supplied by that limited tool of knowledge, the evidence of the senses.

Reality grasped by thought and the understanding is an infinite reality, whereas that grasped by the senses is always limited. Bruno brought out the rationalist and platonist aspects of Copernicus, the Copernicus who could not accept thinking that was "blown hither and thither", but who based everything on reason, because for him reason was the divine, the absolute, the infinite. So bold was this way of thinking that it had overthrown a thousand-year-old scientific tradition.

Thus Copernicus, the last fine flower of the ancient era, was soon to trigger off a new and historic phase of human culture. Towards the end of the 16th century the perennial dialectic of the finite and the infinite saw the intuition of the infinite re-emerge and win the day, thanks to an astronomy which itself had not yet dared to postulate the infinity of the universe.

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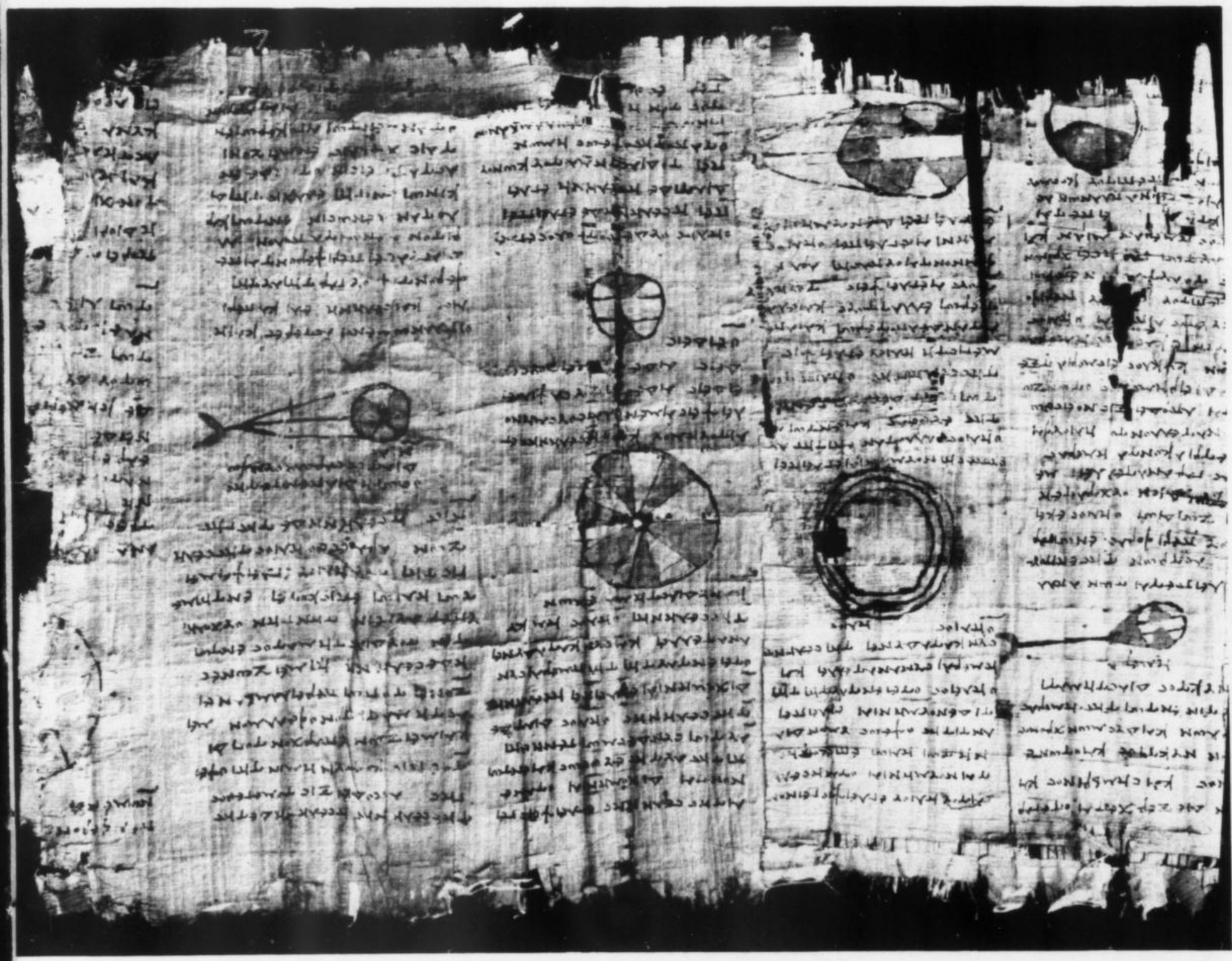

Photo © Chuzeville - Louvre Museum, Paris

PTOLEMY SCANS THE CIRCLING STARS. "I know that I am mortal and ephemeral, but when I scan the circling spirals of the stars, no longer do I touch earth with my feet, but sit with Zeus himself..." wrote Claudius Ptolemy, the 2nd century Graeco-Egyptian astronomer and mathematician. Left, a wooden figure of Ptolemy in Ulm Cathedral (Fed. Rep. of Germany) carved by Jörg Syrlin, a famous 15th century German craftsman. Ptolemy holds an armillary sphere (see pages 24-25). Above, the Letronne Papyrus, the oldest known illustrated Greek papyrus, inscribed with texts on astronomy. Dating from the 2nd century B.C., it contains instructions about the celestial spheres based on propositions by Eudoxus, a 4th century B.C. Greek scholar. Crudely drawn diagrams of the constellations and the zodiac are interspersed with the text.

The Copernican world, it should be stressed, was a finite world; the world was finite, but not reality, since reality was thought and thought went beyond all boundaries, all specific ideas or systems. One of the heretical propositions that sent Bruno to the stake on February 17, 1600, concerned the plurality of worlds. Do many worlds exist? Or are there many notions of worlds which might exist?

Perhaps Copernicus had little inkling of the dramatic developments that would result from the repudiation of the long-established compromise between the senses and reason embodied in the Ptolemaic scheme of the universe. At the time there were no immediate repercussions. But later, in an Italy disturbed and stripped of its preconceived ideas by the Renaissance, the argument about the infinite exploded, involving not only the macrocosm but also the human microcosm.

Bruno read Copernicus in literal and metaphorical terms, just as others, in the past had read Aristotle and Genesis. Some interpretations were erroneous. A theory of the dissolving of the solid heavenly spheres was attributed to Copernicus which appears, to say the least, doubtful to anyone reading *De revolutionibus* with care. But what *was* authentic was the re-affirmation of the infinite in man's reason and the intuition of a new path towards the absolute and towards necessity.

When he died for refusing to recant, Bruno bore witness to the anguish that the problem of reality creates in the minds of men, to the enduring value of the Socratic plea to question all things, and to human civilization's need for the toleration denied it by Calvin's Geneva and the Rome of the Inquisition.

Bruno had come to understand that finite and infinite could become merged in the individual. The individual is finite and limited because he is not other individuals; but he is infinite and unlimited because he is unconditionally himself. The wonderful precision and clarity of the Copernican scheme of things were given new depth and transmuted into this new dimension of human consciousness—individuality.

Galileo was destined to become the finest example of this individuality. What shines out from each of his pages is the workings of a mind whose thoughts become precise enunciations of things, postulates, theorems, problems. Each time, the limitations of "the experiences of the senses" is transcended by the infinity of reason and converted into the individuality of affirmation. And this is why Galileo has for us the intense fascination of the completely modern man, the man for all seasons and of all places.

The Copernicus brought back to life by Galileo in his *Dialogue* is the defender of logical evidence against authoritarianism, verbalism, and the surrender of human responsibility. He is a figure of not only intellectual but also moral virtue, with a clarity of mind which is also a kind of courage, the courage which enabled the new science to develop its own fertility in face of "the over-cautious and jealous protagonists of the immutability of the heavens."

In short, as seen by Galileo, Copernicus the rationalist appears as the father and guarantor of Copernicus the cosmologist. The astounding, sensational astronomical revelation had been preceded by a subjective, internal revelation. Emerging from

the mind of the canon of Frombork (Copernicus), it was transmitted to the Dominican of Nola (Bruno) to appear again refined and intensified in the thinking of the mathematician of the Medici court (Galileo).

Whilst the ancient world had transcended its metaphysical naturalism with the creation by its greatest thinkers of a theory of knowledge, the modern era saw Copernicus, Bruno and Galileo united in an effort to establish a concept of existence that would be open to the requirement of infinity.

Individuality and the individual were their goal—individuality as the recognizable origin of everything. Copernicus' recurrent fears about the consequences of his own theories, the stake at which Bruno died, and the trial of Galileo bear witness to the liberating power of this revolution born of man, projected into the heavens and then embodied in the theory of existence itself.

Sterile scientific tradition, false philosophical reasoning, and religious idolatry may succeed in imposing themselves by force, but they will always be condemned by the judgment of history and the example given by "the innovators" to succeeding generations. ■

EUREKA ! It is through the famous 3rd century B.C. mathematician and inventor, Archimedes of Syracuse, that we have learned about the heliocentric theory of the universe advanced at that time by Aristarchus of Samos. In his book, "Arenarius", Archimedes describes some of the ideas held by Aristarchus. Below, this 16th century engraving illustrates Archimedes' famous bath-night discovery of the principle of the displacement of water. Overjoyed by his discovery, Archimedes is said to have leaped from the bath shouting "Eureka!" ("I have found it"). Near the bath are gold and silver vessels and a crown used by Archimedes for his experiment.

Photo © Bibliothèque Nationale, Paris.
Taken from "Baukunst", by Walter Ryff, Basel, 1582

TRUTH ON TRIAL. "Noble Copernicus, from my earliest youth your works captured my imagination", wrote the Italian Renaissance scholar Giordano Bruno (left, in a 19th century drawing). Born in Nola (Italy) in 1548, Bruno studied, taught and travelled in Italy, France, England and Germany. Challenging the conception of a finite universe, he postulated its infinity, picturing it as a multitude of worlds (celestial bodies substantially similar to the Earth). Denounced to the Inquisition for heresy, he was condemned and burned at the stake in Rome, in 1600. No less imprudent for that time were the ideas defended by the Italian astronomer and mathematician, Galileo (1564-1642). Upholding the Copernican system of the universe, Galileo made observations with his famous telescope that proved the validity of Copernicus' theories. But his assertions brought him into conflict with the beliefs of the Church (still based on the views of Aristotle and Ptolemy). He was brought before the Inquisition and at the end of a trial lasting 20 days he was forced to abjure his ideas. Below, Galileo before his judges, a scene depicted by Robert-Fleury, a 19th century French painter.

Photos © Roger Viollet, Paris

Further reading on Copernicus and astronomy

Nicholas Copernicus: *Complete Works, I : The Manuscript of Nicholas Copernicus - On the Revolutions.* Facsimile. London, Warsaw, Cracow, Macmillan and Polish Scientific Publishers, 1972. Edition sponsored by the Committee and the Institute for the History of Science and Technology of the Polish Academy of Science. Volume I edited by Pawel Czartoryski. Introduction by Jerzy Zathey. Translated by Zygmunt Nierada and Erna Hilfstein. Supervised by Edward Rosen. Reproduction technique by Jan Dorocinski.

Angus Armitage: *Sun, Stand Thou still : The Life and Work of Copernicus, the Astronomer.* New York, 1947, London, 1948.

Marian Biskup and Jerzy Dobrzycki: *Copernicus, Scholar and Citizen,* Interpress Publishers, Warsaw, 1972.

I. Bernard Cohen: *The Birth of a New Physics : From Copernicus to Newton.* Doubleday, Garden City, 1960.

J.L.E. Dreyer: *A History of Astronomy, from Thales to Kepler.* New York, 1953.

Galileo Galilei: *Discoveries and opinions of Galileo.* Translated by Stillman Drake. Doubleday, Garden City. N. Y., 1957.

Sidney Greenberg. *The Infinite in Giordano Bruno,* with a translation of his dialogue: "Concerning the cause, principle and unity." King's Crown Press, N. Y., 1950.

Kenneth Heuer: *City of the Stargazers, the rise and fall of ancient Alexandria,* Charles Scribner's Sons, New York, 1972.

Robert Jastrow : *Red Giants and White Dwarfs.* A Signet science book (paperback), The New American Library Inc., New York, 1969.

Arthur Koestler: *The Sleepwalkers : a History of Man's Changing Vision of the Universe.* Macmillan, New York, Hutchinson, London, 1959.

Thomas Kuhn: *The Copernican Revolution.* Vintage Books, New York, 1959.

Erich Lessing: *Discoverers of Space,* with introduction by Sir Bernard Lovell, Burns and Oates, London, 1969.

Stefan Mekarski: *Nicholas Copernicus,* The Polish Cultural Foundation, London, 1973.

Jerome R. Ravetz: *Astronomy and Cosmology in the Achievement of Nicolaus Copernicus.* Wroclaw, Warsaw and Cracow, 1965.

Edward Rosen: *Three Copernican Treatises : The Commentariolus of Copernicus, The Letter against Werner, The Narratio prima of Rheticus.* Third Edition revised with a Biography of Copernicus and Copernicus Bibliographies, 1939-1958 and 1959-1970. Octagon Books, New York, 1971.

Eugenius Rybka: *Four Hundred Years of the Copernican Heritage.* Jagiellonian University, Cracow, 1964.

Giorgio de Santillana : *The Crime of Galileo.* Univ. of Chicago Press, 1955 ; Heinemann, London, 1958.

Jagjit Singh : *Modern Cosmology.* A Pelican Book, Penguin Books Ltd., U.K., 1970.

Dorothy Stimson: *The Gradual Acceptance of the Copernicus Theory of the Universe.* New York.

A. Wolf: *A History of Science, Technology and Philosophy* in the 16th and 17th Centuries. Second edition, New York, 1950.

The text below by the Director-General of Unesco, René Maheu, has just appeared in a limited edition monograph published by the Polish National Commission for Unesco, in co-operation with Unesco, on the occasion of the ceremonies organized in Paris on February 19, 1973, to mark the 500th anniversary of the birth of Copernicus. The monograph, printed in 2,000 copies on paper specially hand-made in Poland, is not on sale. It contains the texts of the addresses delivered at the Unesco-sponsored ceremonies by René Maheu, Janusz Groszkowski, Member of the Polish Academy of Sciences, Olaf Pedersen, Member of the International Union of the History and Philosophy of Science, and by Umberto Forti, science historian.
Right, an illustration from the monograph, the frontispiece to Galileo's Dialogus de Systemate Mundi, *showing, from left to right, Aristotle, Ptolemy and Copernicus.*

A NEW VISION OF THE UNIVERSE

by René Maheu
Director-General of Unesco

HISTORY affords few examples of scientific discoveries that have had such profound repercussions on the spiritual development of mankind as that of the great Polish astronomer Nicholas Copernicus. Unlike later discoveries, such as those of Ampère or Faraday, the replacement of the Ptolemaic model of the solar system by the Copernican conception did not lead to any technological innovations. It did, however, bring about a veritable intellectual revolution, which had a profound and far-reaching effect upon man's conception of his place in the universe and hence of the human condition itself.

Man now realized that he was living on a planet which was spinning through the immensity of a universe whose dimensions were beyond his imagining; but at the same time he became convinced that human thought was capable of grasping the laws which govern that universe and of predicting the motions of the heavenly bodies. Before he could arrive at such a conviction, however, he had to discard many preconceived ideas which had hardly changed since the days of Aristotle, and to cease regarding himself as the centre of the universe.

This liberating experience opened the way for other discoveries which have gradually shaped our present view of man's place and purpose in nature, for it is through the realization of his own physical insignificance in relation to the universe around him that man has come to appreciate his true greatness, which is spiritual.

Astronomers today have at their disposal instruments that are infinitely more powerful and accurate than the simple armillary sphere and astrolabe with which Copernicus and his contemporaries worked. Giant radio-telescopes and spacecraft supply them with information about phenomena previously beyond their ken; but in the last analysis creative imagination, stimulated by insatiable curiosity, remains the decisive factor in intellectual progress.

Thus, despite the five hundred years that separate us from him, the force of his genius still keeps Nicholas Copernicus close to us. In paying tribute to him, we reaffirm our faith in man and in man's constantly renewed ability to master, by the sheer power of rational thought, a universe whose outlines forever elude him and whose scale and complexity offer an unending challenge to human intelligence.

Letters to the Editor

THE ORIGINS OF MAN 300-PERSON PROTEST —TWO OTHER VIEWS

Sir,

I am not a professional anthropologist, but I would like to reply to Dr. J. Hildesheimer's letter in your January 1973 issue. Writing on behalf of over 300 other persons, she complains that your issue, "The Emergence of Man" (August-September 1972), neglects the question of man's spiritual origins.

I see no reason for the protest since the presentation of non-scientific theories was outside the scope of the issue. Dr. Hildesheimer writes that man has questioned himself about his origins during thousands of years, and has come up with a wide range of answers. Man has asked himself many other questions — about the solar system for example — and these resulted in many replies too. Yet most of them are now only of historical interest, and it is the Copernican answer that has remained as a true account of reality.

I am against the practice of referring to the views of prominent scientists in fields other than their own in support of a particular point of view. Einstein's views on the origins of man are of great interest as the opinions of a great man, but they can hardly be considered as a contribution to palaeontology.

Although I am not against the religious attitude expressed in the letter, I do deplore the situation in which an ideology blinds critical judgement. I count many believers among my friends, but our differences of view do not affect our friendship, perhaps because we realize that acceptance or rejection of the existence of a "higher wisdom" is not subject to evident proof, but is a matter of convictions and inner needs.

Dr. Ludwik Czaja
Warsaw, Poland

Sir,

Dr. J. Hildesheimer and 311 co-signatories protest against the fact that your issue on the emergence of Man dealt with the question solely from the biological and evolutionist point of view, and that no mention was made of the concept of a creation directed by higher powers. "In the records of great religions and nations", says the letter, "as well as in modern spiritual research, may be found a host of references to and proofs for the physical-soulful-spiritual origin of mankind."

Unesco, however, is one of the few organizations that is truly universal in character, but this universality, can only be maintained if Unesco deliberately refrains from adopting a particular stand on religious or ideological matters.

Unesco's objective is to bring the peoples of the world closer together through the common study of the phenomena and laws of nature and of human relations, and to seek a general, world-wide philosophy without identifying itself with or making judgements about the beliefs and teachings of the world's many religions and ideologies. This is an essential condition of the universality of Unesco and of the services it provides and can provide. The fact that the issue of the "Unesco Courier" criticized by your correspondents abstains from raising the problem of man's divine inspiration is in accordance with this principle and should be taken as a mark of deference to the world's religions.

Robert L. Hatt
Bern, Switzerland

UNDERWATER VANDALS

Sir,

I am preparing a book on underwater archaeology, with emphasis on damage done by treasure-hunters who loot wrecks. If any readers can furnish information on this I should be grateful to receive it. I'm particularly interested in hearing about Latin America and the Pacific, for which little information seems available at present. However, information from any area is more than welcome.

Herb Greer
c/o Film Rights, Ltd
113-117 Wardour St.
London W1V 4EH, U.K.

VANISHING CULTURES

Sir,

One problem that worries me is the fate of the world's primitive cultures, in particular Indians of the Amazon.

International campaigns have been launched to safeguard animals threatened with extinction. Surely it is more important to save human beings and their cultures from being wiped out. Cannot Unesco co-ordinate the so far dispersed and fragmentary efforts that have been made to protect the world's primitive cultures?

Yves Guillon
Rennes, France

STOCKHOLM FOLLOW-UP

Sir,

Congratulations on your excellent issue on man and the environment (January 1973). Although human settlements were one of the themes of the agenda paper, they were little discussed at The U.N. Conference on the Human Environment, in Stockholm. Unesco should not propagate the image of environmental concern as concentrated on the disappearing species of animals and wilderness forests.

"The human environment" encompasses the urban slums, the favellas, barrios, freetowns, Wildsiedlungen on every continent. The United Nations has accepted the invitation of the Government of Canada to convene an exhibition-conference in Vancouver, in September, 1975, to concentrate on the issues neglected at Stockholm.

The Secretary-General of the Stockholm Conference, Mr. Maurice Strong, adduced a statistic that is frightening. Of the pollution in the oceans, one quarter derives from oil spills, discharges from vessels, the effluent of polluted rivers. But three-quarters begins as the exhaust from automobiles, mostly in cities, carried into the clouds and dropped in the oceans in rain.

It is for this reason that the International Union of Local Authorities, which has long enjoyed fruitful relations with Unesco, convened a meeting of municipal officials in Vienna in November, 1972: "After Stockholm—What?".

Charles S. Ascher
New York

RECIPE FOR HEALTHY SOIL

Sir,

I was astonished by Mr. Metrallet's letter in praise of organic farming published in the your October 1972 issue. This matter deserves to be examined more seriously; the systematic opposition of chemical and organic farming methods simply does not conform to the facts since everyone knows that soil must be treated with both minerals and humus if its fertility is to be maintained.

It is intellectually dishonest to speak of record crops achieved by the use of vegetable compost alone, without making it clear that such composts are derived from vast quantities of vegetable matter gathered from forests, dunes and fallow land, involving a great deal of labour and resulting inevitably in the impoverishment of the land from which it was taken.

Mr. Metrallet sings the merits of "food obtained from a balanced soil". But who wants the soil to be unbalanced? Everyone knows that most soils, naturally or as the result of prolonged agricultural use, are impoverished and unbalanced. Compost alone cannot replace the elements extracted by the growth of crops and whose absence gives lower yield and quality.

R. Gervy
National Federation of Fertilizer Industries
Paris, France

MODELLED ON NATURE?

Sir,

I was particularly struck by the photograph at the bottom of page 19 in your February 1973 issue, illustrating the article on the ancient Thracians in Bulgaria. The photo showed a decorated libation bowl originating from Lampsakos on the coast of the Sea of Marmara (photo left).

There seems to me to be little doubt that the craftsman who made this bowl drew his inspiration from fossilized Echinida (sea-urchins) such as are also found in Bulgaria. I am thinking particularly of the *Porosoma* (photo right) or *Phymotaxis* varieties, though many others, very similar in appearance, have been found in outcrops of tertiary and cretaceous rock.

Dr. H. J. Oertli
Pau, France

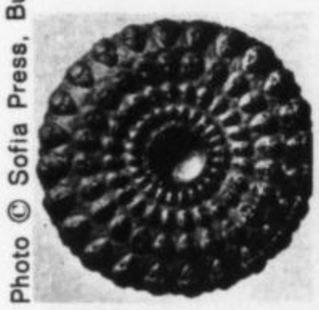

Photo © Sofia Press, Bulgaria

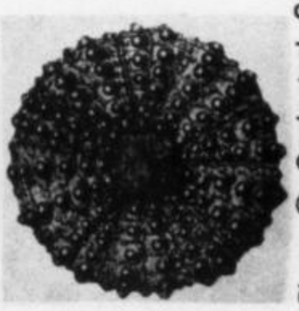

Photo © Geological Soc. of America and Univ. of Kansas Press

BOOKSHELF

■ **The United Nations System: An Analysis,** by Mahdi Elmandjra. Preface by Prof. Gunnar Myrdal and Postface by Sir Robert Jackson. Faber and Faber, London, 1973 (£6); Archon Books, Hamden, Connecticut.

■ **Seven Voices: Seven Latin American writers talk to Rita Guibert.** Translated from the Spanish by Frances Partridge; introduction by Emir Rodriguez Monegal, Alfred A. Knopf, New York, 1973 ($10).

■ **Tracing Shamans in Siberia: The story of an ethnographical research expedition,** by Vilmos Diószegi. Translated from the Hungarian by Anita Rajkay Babó. Anthropological Publications, Oosterhout, The Netherlands 1968; U.S. distributor: Humanities Press Inc., New York.

■ **Bibliografia General de la Literatura Latinoamericana.** Contributors: G. Lohman Villena y L. Jaime Cisneros (Periodo colonial); Julio Ortega (Siglo XIX); H. Jorge Becco (Epoca contemporánea). Coordinador: Jorge Carrera Andrade; Revisor: Héctor Luis Arena. Co-edition Unesco - Editions Siglo XXI, Mexico City. 1972 (14 F).

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UNESCO'S TRANSLATION SERIES

CHINA

■ **Poems of Solitude,** translated by Jerome Ch'ên and Michael Bullock. Lund Humphries Publishers Ltd., Bradford and London, 1960, 2nd Ed. 1970, 118 pp (£1.80); Charles Tuttle Co., Tokyo and Rutland, Vermont ($6.50)

INDIA

■ **Avimaraka (Love's Enchanted World),** translated by J.L. Masson and D.D. Kosambi. Motilal Banarsidass, Delhi 1970, 151 pp (18 Rs.)

■ **Hymns of Guru Nanak,** translated by Khushwant Singh. Orient Longmans Ltd., New Delhi, 1969, 192 pp. (paper, 7.50 Rs.; cloth 12.50 Rs.)

ISRAEL

■ **Pictures from a Brewery,** by Asher Barash, translated by Katie Kaplan. Peter Owen Ltd., London, 1972, 270 pp (£2.50)

IAPAN

■ **The Sound of the Mountain,** by Yasunari Kawabata, translated by Edward M. Seidensticker. Secker and Warburg Ltd., London, 1971, 276pp (£2.25); Knopf, N.York ($7.50)

KHMER REPUBLIC

■ **Mr. Basket Knife and other Khmer folktales,** translated by Anthony Milne, illustrations by Sisowath Kulachad. George Allen and Unwin Ltd., London, 1972, 62 pp (£1.50)

KOREA

■ **Songs of the Dragons,** translated by James Hoyt. Korean National Commission for Unesco, for the Royal Asiatic Society, Seoul, 1971

UNESCO NEWSROOM

U.S.S.R. joins Universal Copyright Convention

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BOOKSHELF

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■ **Seven Voices: Seven Latin American writers talk to Rita Guibert.** Translated from the Spanish by Frances Partridge; introduction by Emir Rodriguez Monegal, Alfred A. Knopf, New York, 1973 ($10).

■ **Tracing Shamans in Siberia: The story of an ethnographical research expedition,** by Vilmos Diószegi. Translated from the Hungarian by Anita Rajkay Babó. Anthropological Publications, Oosterhout, The Netherlands 1968; U.S. distributor: Humanities Press Inc., New York.

■ **Bibliografia General de la Literatura Latinoamericana.** Contributors: G. Lohman Villena y L. Jaime Cisneros (Periodo colonial); Julio Ortega (Siglo XIX); H. Jorge Becco (Epoca contemporánea). Coordinador: Jorge Carrera Andrade; Revisor: Héctor Luis Arena. Co-edition Unesco - Editions Siglo XXI, Mexico City. 1972 (14 F).

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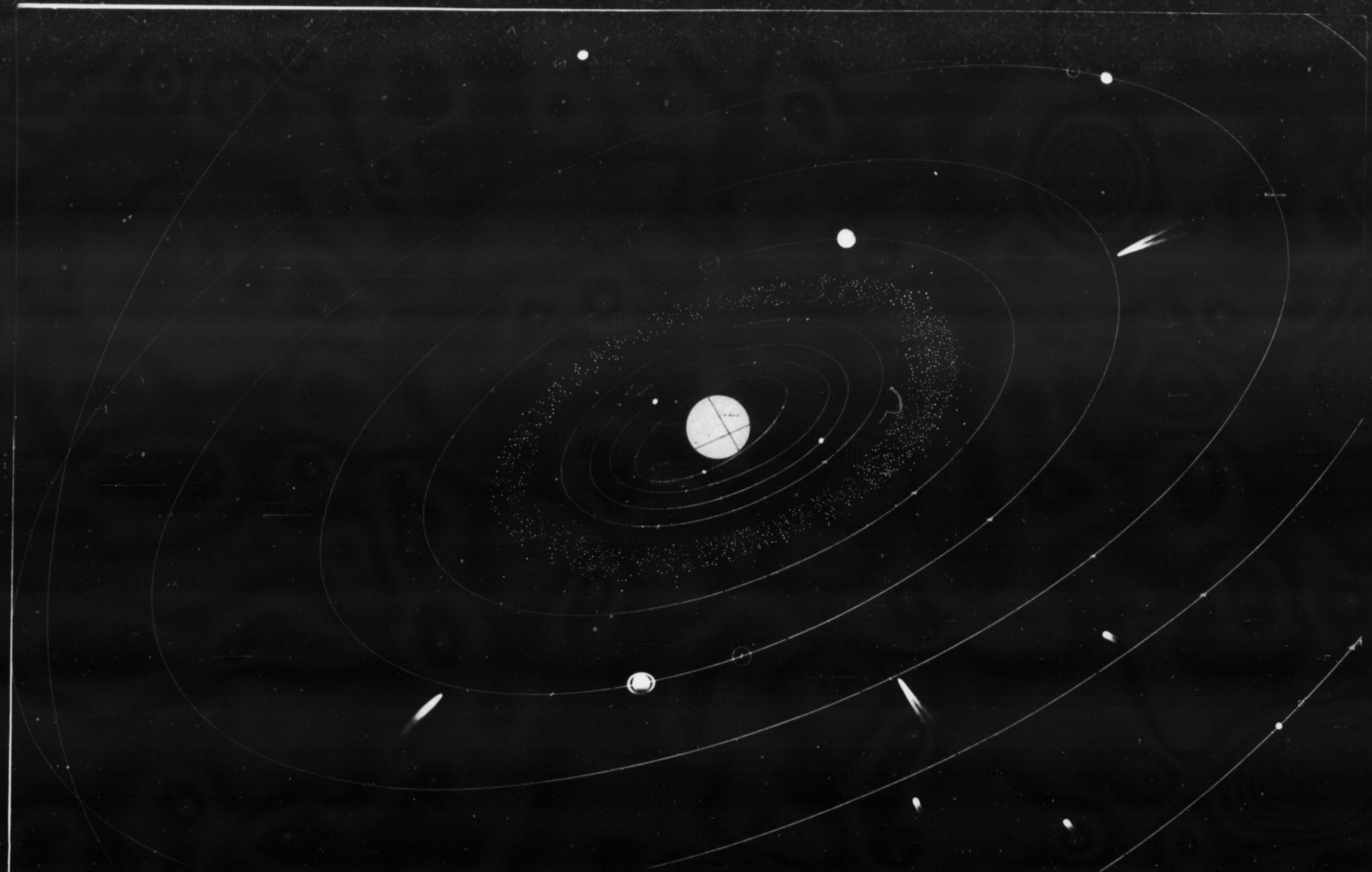

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THE SOLAR SYSTEM *(see page 3)*